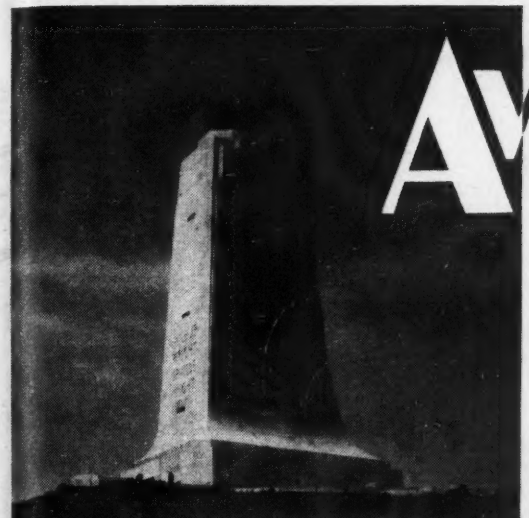

AVIATION

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Aviation is indexed in Guide to Periodical Literature and in Industrial Arts Index.

Balancing a life ~~dynamotor~~...

Maetta Lambert knows why each armature that goes into the Altair* dynamotors must be patiently balanced. Miss Lambert has two brothers in the service.

Altair* dynamotor armatures are balanced both statically and dynamically as but one of many tests and inspections of this precision product before it is installed in the vital electrical, communication and radio equipment manufactured by Pacific Division.

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**The new trade name of Pacific Division, Bendix Aviation Corporation.*

Typical of the use being made of Altair dynamotors is the compact installation being made in Interphone Amplifier equipment which the Pacific Division supplies for many fighting planes.

Pacific Division
Bendix Aviation Corporation
(Formerly Bendix Aviation, Ltd.)
NORTH HOLLYWOOD, CALIF.

DESIGNERS AND MANUFACTURERS OF RADIO AND HYDRAULIC EQUIPMENT — OUR PART OF THE INVISIBLE

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Briefing for May

Aircraft markets comprise a $64 question and their determination is probably the most sought after image in the great game of postwar crystal ball gazing. Associate Editor Foster rejects the gazing principle in this issue and begins a comprehensive state-by-state region-by-region survey, analyzing basic data needed to calculate aircraft distribution potential in every part of the country. This important series—the first of its kind to be published for the industry—begins on page 110.

We are now entering the age of prefabrication and it is bound to have a revolutionary effect on our social and economic existence. The aviation industry is more than keeping pace, and now Westinghouse Electric International presents—wrapped in a ribbon, if you like—a packaged airport! Yessir, everything from plumbing to terminal buildings in infinite combinations to suit all requirements. You can have it delivered air express, too. Shall we wrap it, sir? For details on this engineering miracle see page 116, then be sure to discard the word "can't" from your vocabulary.

Last month, Capt. C. H. Schildhauer, of the Naval Air Transport Service, realistically sized up the global air transport routes of the future and advanced his technical reasons for the flying boat's coming into its own. After that thorough and severe salvo, he now steams in with *coup de grace* torpedoes in the form of economics to show that the flying boat boasts advantages over the land plane in the coming race for low cost international transport. The hits are scored on page 119.

Judging by the way letters constantly pour in urging us to "keep up" our famous "design analyses," you'd think we intended to stop them. Not a chance. We know how valuable they are, and furthermore it's darned interesting work. You readers have led us into a vicious trap with your enthusiastic response. The editors are hell-bent for "out-analyzing" each other. Result: Bigger and better design analyses. Detroit Editor Ricker really extended himself in his job on the famed deHavilland *Mosquito,* which begins on page 127. So much so, in fact, that we just had to break it into two installments, the second to be published next month. Packed with superbly executed sketches and supported by most comprehensive text, this engineering treatise is an important addition to your growing design library.

Wind tunnel technique comes under the heading of "basic research," (see editorial on page 109). Determination of airfoil pressure distribution is one of the important employments of wind tunnels. Practical step-by-step procedure for conducting this research is outlined by Monroe Maller, of Hughes Aircraft, on 141.

Sir Geoffrey deHavilland, *whose famous Mosquito bomber is described in Aviation's 6th Design Analysis on page 127. (From a painting by Oswold Birley.)*

Chevrolet and Frigidaire have teamed up—with a striking degree of efficiency—to produce Hamilton Standard propellers. Complete details of their high-production procedure is outlined "From Billet To Blade" (page 145).

Radio precipitation static is further discussed in the second installment of C. J. Breitwieser's article—page 151. Present methods of noise reduction are treated, and indications of probable final solutions to the problem are given.

A great many factors are involved in the determination of true airspeed. Richard G. Smith, of United Aircraft, offers a set of nomographs which give positive solutions in a minimum of time (page 154).

The advent of AN standards for aircraft tube, pipe, and hose fittings presents a problem when operators wish to change over in the interests of standardization. American Airlines has prepared a series of charts giving standards equivalents, and we present them in their entirety, beginning on page 165. They are invaluable guides to engineers and maintenance men.

A fighter pilot would seem to have enough to do without being a mechanical troubleshooter, too. Yet, Lt. John S. Miller returns from the South Pacific with some practical advice for new pilots on the value of knowing the airplane and being able to diagnose trouble when it occurs. It saves incalculable maintenance man-hours and makes for a far more efficient fighting unit. His story is on page 187.

Down the Years in AVIATION'S Log

25 Yr. Ago (1919)—NC-4 seaplane (Lt. Comdr. A. C. Read, USN) flies in stages from Newfoundland to Plymouth, Eng. . . . Hawker and Grieve, starting for Ireland from Newfoundland, are forced down in Atlantic and picked up by Danish steamer. . . . Navy orders six Loening monoplanes for catapult launching from battleships. . . . Army considers transcontinental test flight. . . . First Holland air show held in Amsterdam. . . . Curtiss Corp. buys 2,176 airplanes and 4,608 engines from government for redistribution. . . . U. S. Army airship A-4 lands passengers on roof of Cleveland hotel. . . . Lt. Roget and Capt Coli, French Air Service, fly non-stop from Paris to Morocco, 1,116 mi. in 11 hr. 50 min.

15 Yr. Ago (1929)—Congress introduces bill authorizing loan to manufacturers of scarce aeronautical design and research equipment. . . . Elinor Smith of Freeport, L. I., N. Y., stays in air 26 hr. 21 min., breaking women's record. . . . Curtiss-Robertson plant turns out 16 planes per week. . . . Boeing turns out 165-mph., *Wasp*-engine "fighter type" sport plane. . . . Newly formed Curtiss-Caproni Corp. starts factory at Baltimore. . . . Army LB-7 twin-engine bomber flies from Dayton, "bombs" New York city, and returns to base (1,544 mi. non-stop, refuelling twice in air). . . . Army expedition leaves to make aerial survey of Alaska . . . Rickenbacker announces Allison Engineering Co. will spend $1,000,000 for airplane engine plant. . . . Stinson announces plans for 400-plane output for 1929. . . . Navy opens 1-yr. ground school course at University of California. . . . Newark Airport Realty Co. formed to finance building Newark, N. J., airport.

10 Yr. Ago (1934)—Sikorsky S-42 climbs to 21,800 ft. with 11,000-lb. payload. . . . Post Office issues new airmail contracts to civilian contractors. . . . German Foreign Minister says Fatherland's expenditure of $63,000,000 on aviation was for airline development only. . . . William Thaw, first American commander of Lafayette Escadrille, dies in Pittsburgh. . . . TWA inaugurates N. Y.-Pittsburgh run. . . . American Airways announces sleeper service between Dallas, Ft. Worth, and Los Angeles.

INCREASED RANGE for civil and military aircraft through more precise power output control is the objective of Kollsman development in engine instruments. That is the function of the new Kollsman Horsepower Indicator. Activated by the hydraulic torque balance unit of the propeller reduction gear, it permits direct reading of B.M.E.P. and, when R.P.M. is set on a sub-dial, net shaft horsepower is also read directly. The instrument was developed in coöperation with N.A.C.A. and leading engine manufacturers.

KOLLSMAN AIRCRAFT INSTRUMENTS

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ELMHURST, NEW YORK GLENDALE, CALIFORNIA

THE CRITICS STAND REFUTED

And Sound Engineering Will Keep Them That Way

In October 1942 it became urgently necessary to devote these columns to a severe indictment of the critics of American combat aircraft. A procession of insidious Congressmen and columnists had been playing the age-old game of promoting themselves at the expense of aviation.

Our righteous indignation was not prompted primarily by a desire to defend the aircraft industry, even though it should have been defended if the nation was to be defended. It was prompted by the shocking realization that armchair strategists and overnight experts were incalculably damaging morale of the young men going out to fight our battles.

The war had torn these youths away from football teams or varsity crews for rapid transformation into legal killers and they were flying out to war with deep-rooted reservations about the quality of their weapons compared with those they were to meet in battle. Most of the newspapers of the nation and many of the sounder columnists cooperated with us splendidly in helping to spread the truth about our airplanes.

We began by telling the story of a typical young pilot who came into our office for reassurance, a new pair of wings on his breast and a troubled look on his face. Time passed, then a few weeks ago this same young man returned to us after more than a year of action in a war theater where quarter is neither asked nor given. This time he was wearing a campaign ribbon with two stars, an Air Medal ribbon, a Distinguished Flying Cross ribbon, and a Presidential Citation ribbon with one cluster, a second to be added soon. Flying in one of the most-maligned fighter aircraft of the war, he had succeeded in completing nearly 100 combat missions. His group had scored over 400 victories at an established ratio of better than 30 to 1 over the enemy. His squadron had lost but seven pilots in nearly two years of combat. Quite a record for "no-account" and "obsolete" airplanes!

This brilliant performance of American pilots and planes is not an isolated case. On all the fighting fronts our men and planes are proving irrefutably that each of them is more than equal in courage and quality to many of those of our enemies. Truly we have no apologies to make for any of our flying equipment.

But this is neither the time nor the place for resting upon our hard-won laurels. Let us remember that our enemies have brains, too, and that they are not sitting idly by waiting for us to design new and even better planes. We should be neither surprised nor disconcerted if some of the brain children of Papa Heinkel, Willy Messerschmitt, or Herr H. Focke appear over the Western front in the form of new spring models. These ingenious minds have been working for quite a while and some results are about due.

It may be that this will be the Nazis' last fling and we can look upon the battle to be enjoined with confidence that our own present and forthcoming equipment will prove superior to anything the enemy is likely to introduce. At the same time we feel certain that the test will tax both our ingenuity and design to the utmost and we fervently trust that allowance is being made for protracted effort. That allowance can only take the form of *continued* qualitative superiority achieved through endless research and engineering development.

We must remember that the Nazis elected to freeze design and to concentrate on numbers. This decision, which in effect was to divert their energies away from research and development, is one of the principal reasons for *our* standing on the threshold of victory—where the Nazis once stood. The position is reversed in some respects, hence we must take caution. Our enemies have gone back with much vigor to basic research. Whether at war or at peace, let us not relax—ever!

Leslie E. Neville

Editor

HERE ARE YOUR MARKETS

PART I—MIDDLE ATLANTIC, NEW ENGLAND, AND SOUTH ATLANTIC REGIONS

By JOHN FOSTER, Jr., *Associate Editor, "Aviation"*

Presenting a comprehensive state-by-state and region-by-region survey—the first ever published for the aviation industry—analyzing data for the determination of a sound distribution network.

MERCHANDISING ITS PRODUCTS has always been one of the toughest and, in many cases, most sorely neglected problems faced by the aircraft industry.

In the not-too-profitable past, airplane distribution has too often been a hit or miss proposition; too often the distributor-dealer set-ups, like Topsy, "jest growed." If production for private flying is to reach profitable proportions, the prime requisite is establishment of complete, well organized distribution organizations. "You gotta sell 'em if you want to keep making 'em" is an axiom that will apply to aircraft production as much as it has to production of automobiles or washing machines.

In any attempt to set up such a distribution organization, the first step is to gather and correlate information that will answer two principal questions: Who are the potential customers? And where are they?

As a service to the industry, AVIATION is presenting through this series some of the basic information to answer these and other vital questions—information which reveals, for example, that New York, Pennsylvania, and California show up as the best individual aircraft market states, and that these three states are salient in two of the three best marketing regions.

The information will be arranged to be of value not only to manufacturers but to those who would continue to be, or plan to become, aircraft or accessory and parts distributors or dealers. Thus, for each state and region there will be presented the following data:

1. Total family population. This measure of determining the number of potential customers is used largely because the families are felt to comprise the greatest portion of the aircraft market and because in this classification usable statistics are readily available.

2. The percentage of each state's and region's family population, each related to the United States as a whole.

3. Percentage of state and regional buying income, each related to the country as a whole. Buying income, defined as "the available spendable money," is the money for which aircraft manufacturers and their distributors will have to compete (against automobile, refrigerator, boat, and all other manufacturers).

4. Percentage of United States retail sales, an added guide to the buying power and buying habits of each state and region.

5. Number of passenger automobiles registered. This is a straight numerical rating, state by state, giving clues both to transportation needs and uses of buying income.

6. Number of passenger autos per 100 families, on a state and regional-range basis.

7. Number of aircraft registered—by state and region—as of Oct. 1, 1941, the latest available peacetime data. This, of course, is one of the best indices of past acceptance of private flying.

8. Percentage of aircraft registrations, by state and region, each related to the country as a whole.

9. Number of non-airline pilots registered by state and region as of Oct. 1, 1941, latest available peacetime data. This also is an important index of past aviation acceptance.

10. Number of airports. Personal plane utility—or lack of it—has always been one of the dominant factors in aircraft sales; the number-of-airports figures serve not only as a measure of utility but also as a guide in picking distributor-dealer locations.

11. Number of airports per 1,000 sq. mi., an added guide for distributor-dealer locations.

12. Percentage of airports. Like other percentage figures, this relates the state and region to the country as a whole, for comparative purposes.

13 & 14. The data as a whole will also be measured by states so that a final market rating of Class A, B, C, D or E can be applied for comparative purposes. Similar measurements will be made for the regions, with the market ratings ranging from first to ninth in importance.

Although the airplane tends to eliminate geographic and economic barriers common to other transportation forms, usable statistical data is available by geographic measure—states and regions—thus the information must necessarily be presented on that basis.

The regions employed in this study are those established by the Chamber of Commerce of the United States and have been most widely accepted in market studies. They are set up as follows:

New England—embracing Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut.

Middle Atlantic—New York, New Jersey, and Pennsylvania.

South Atlantic—Delaware, Maryland, Virginia, West Virginia, North and South Carolina, Georgia, and Florida.

East North Central—Ohio, Indiana, Illinois, Michigan, and Wisconsin.

West North Central—Minnesota, Iowa, Missouri, North and South Dakota, Nebraska and Kansas.

East South Central—Kentucky, Tennessee, Alabama, and Mississippi.

West South Central—Arkansas, Oklahoma, Louisiana, and Texas.

Mountain—Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, and Nevada.

Pacific—California, Oregon, and Washington.

Since, as noted, the airplane tends to eliminate geographic and economic barriers, there will naturally appear to be some overlapping of distribution areas between states and regions, but as the picture for the country as a complete unit takes shape, this apparent overlapping can be obviated.

Acknowledgment

In preparing this series, AVIATION has been greatly aided by Joseph T. Geuting, Jr., vice-president, General Aircraft Corp.; A. T. Hapke, Jr., Republic Aviation Corp.; and E. E. Lothrop, manager, research and statistics department, Aeronautical Chamber of Commerce. Meanwhile, special thanks go to Frank Christian, of H. B. Humphrey Co., who has given most generously of time and counsel.

Middle Atlantic

Because it includes two of the "hottest" states marketwise, and has the No. 1 rating, the Middle Atlantic region will be considered first. The data for its three states of New York, New Jersey, and Pennsylvania, taken "across the board," shape up as shown in Table I.

The heavy concentration of population

in and adjacent to the metropolitan New York City area accounts in a large measure for New York state's high rating in the family population category, as well as for similar ratings in buying income and retail sales. Nevertheless, the state outside this metropolitan area stands up well enough to make it compare favorably with other states as a potential aviation market. This is borne out by the index of transportation needs—passenger automobile ownership—in which New York state leads the nation with 2,286,382 cars.

As to straight aircraft data, however, the Empire State drops off in two phases. Registrations of 1,676 aircraft—7.2 percent of the nation's total—put it in third place, following Pennsylvania and California, which "win" and "show" respectively. In number and percentage of airports—130 and 4.6 New York compares well with other states, but its 2.71 airports per 1,000 sq. mi. put it in seventh place on a nation-wide basis.

It should be noted that, despite the population concentration in and around New York City, just under one-fifth of the state's airports are in that area. The city's most important commercial airport is, to all intents and purposes, closed to the average private flyer. This closing of large commercial airports to personal flying is a factor which must be carefully studied and closely watched in other large centers, both today and as scheduled air transport operations grow.

In considering New York state for distribution of aviation products, it should be remembered that while much of the population and income are concentrated, the state also has a high percentage of rural families—families which often have surprisingly large amounts of "cash money" to spend on better means of transportation. By the same token, much of New York City's population is used to commuting. Although limited to a small group of wealthy businessmen, commutation by air had reached its highest stage of development (before the war) in this area.

While it is impossible to get accurately measurable data on water landing facilities, it must be remembered that New York has a large number of lakes, well distributed over the entire state and usable for eight to nine months of the year. While this might well be an added factor in considering production of amphibious or float planes, it is not at this time believed that actual distribution locations would be greatly altered.

Table I—Middle Atlantic Region

	New York	*New Jersey*	*Pennsylvania*	*Total*
1. Family pop.	3,662,228	1,100,260	2,516,423	7,278,911
2. Percent, nat'l. pop.	10.6	2.9	6.8	20.3
3. Percent, U. S. buying income	12.98	4.3	7.94	25.21
4. Percent, U. S. retail sales	11.03	4.14	7.74	22.91
5. No. passenger cars	2,286,382	875,762	1,781,467	4,943,611
6. No. cars per 100 families	62	80	70	68
7. No. aircraft registered	1,676	655	2,372	4,703
8. Percent aircraft registered	7.2	2.8	10.2	20.2
9. No. pilots registered	6,299	2,281	4,435	13,015
10. No. airports	130	59	155	344
11. Airports per 1,000 sq. mi.	2.71	7.84	3.44	.....
12. Percent airports	4.6	2.0	5.4	12.0
13. State market rating	A	A	A	.....
14. Regional market rating	.....	.....	.....	First

On the basis of measurable data alone, however, New York can be considered a Class A state for the distribution of aviation products. Indeed, it ranks as the most important in the country on a state-by-state basis.

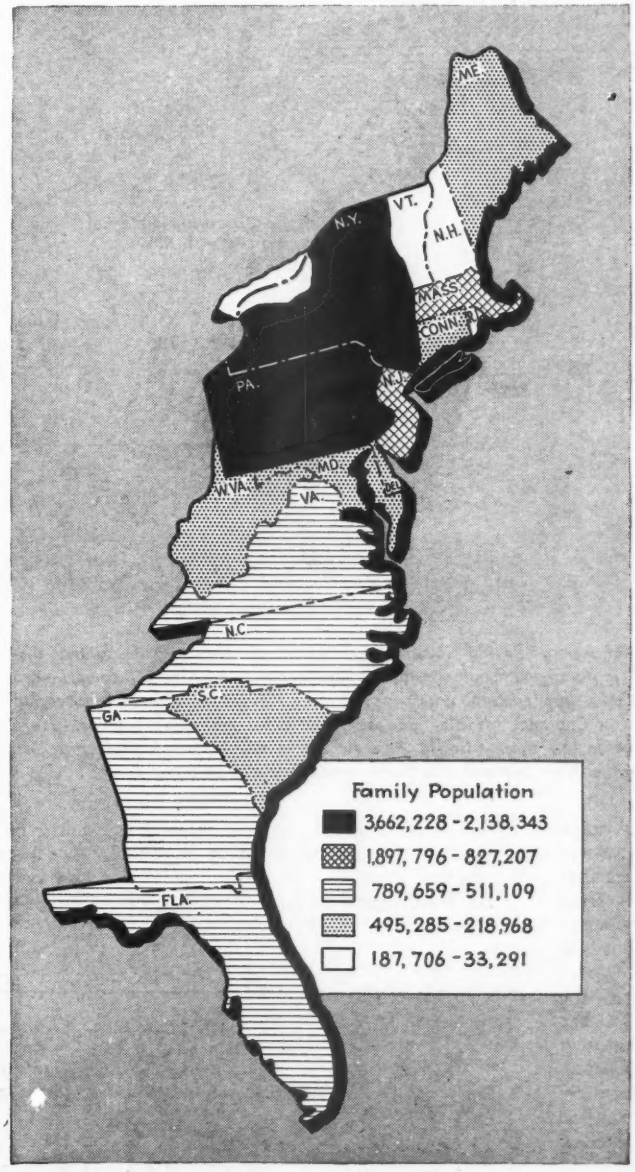
Because of its location adjacent to New York, some of the previously-mentioned overlapping influences have their effect on New Jersey as a marketing area. Although, comparatively, it is small, the state rates well on the basis of the market criteria.

While its family population of 1,100,260 is ony 2.9 percent of the national total, New Jersey accounts for 4.3 percent of the buying income and 4.14 percent of the retail sales, and its ratio of passenger cars owned is about the same as that in New York.

With aircraft registrations totaling 655, New Jersey has 2.8 percent of the country's planes owned; 2,281 non-airline pilots give it a good rating in this respect. With 59 airports—well distributed over the state—New Jersey has 2 percent of the nation's total, but with 7.84 ports per 1,000 sq. mi. it has the best coverage of any state in the union. Many protected harbors along the coast-line and good distribution of usable lakes in the northern summer resort section give New Jersey an excellent position for use of water-based craft over a large part of the year.

Based on the measurable data of family population, buying income, retail sales, automobile ownership, aircraft and pilot registrations, and airport facilities, New Jersey adds up to a Class A market, standing as eighth most important.

As previously indicated, Pennsylvania also measures out as a Class A market, for in practically every category it has a high rating. It encompasses, for example, the third highest percentage of airports—5.4—in the country, being led only by California and Texas, which have 7.8 and 7.7 percent, respectively. Moreover, Pennsylvania's 3.44 ports per 1,000 sq. mi. give it sixth place for the country by this measurement.



Visual comparison of family population ranges in states comprising New England, Middle, and South Atlantic marketing regions, where actual totals run from 92,435 in Vermont up to 3,662,228 in New York. Note that two of three Middle Atlantic states are in highest bracket—shown as solid black—while New England states embrace three of five ranges and South Atlantic two middle brackets.

Geographic distribution of these Keystone State landing facilities is normal, following closely the distribution of population, with airways generally in an east-west direction across the middle of the state. However, a distributor-dealer set-up would undoubtedly be affected by the fact that the state is bisected in a northeast-southwest direction by the Allegheny Mountains and the fact that the northeast part of the state in the anthracite mining region, is likewise largely mountainous. Compared with New York and other states, Pennsylvania does not have a large number of water bodies suitable for amphibious or float plane operations.

With a total family population of 2,516,423, this state has 6.8 percent of the nation's total, accounting for 7.94 percent of the buying income and 7.74 percent of the retail sales. These factors, together with its consistently high aviation ratings, give Pennsylvania its Class A market rating. It's the third most important in the country.

Considering the three states together as the Middle Atlantic Region, these guides develop the following facts:

The combined family population of 7,278,911 accounts for 20.3 percent of the nation's total, giving a numerical answer to one of the main questions: Where are the potential customers? The people in these states have over a quarter—25.21 percent—of the nation's buying income and have accounted for 22.91 percent of the country's retail sales, helping to answer the question: Who are the prospects?

A clue to transportation needs—or at least habit—is given by ownership of 4,943,611 passenger automobiles, or an average of 68 per 100 families. This auto ownership is significant in view of the fact that distances between cities are not great and that other forms of transportation are the most highly developed in the country.

As to past aviation acceptance, the 4,703 registered aircraft represent 20.2 percent of the United States total, closely paralleling the ratio of family population. The 13,015 non-airline pilots, however, are a shade over 14.3 percent of those in the country, and the 344 airports comprise 12 percent of all those available.

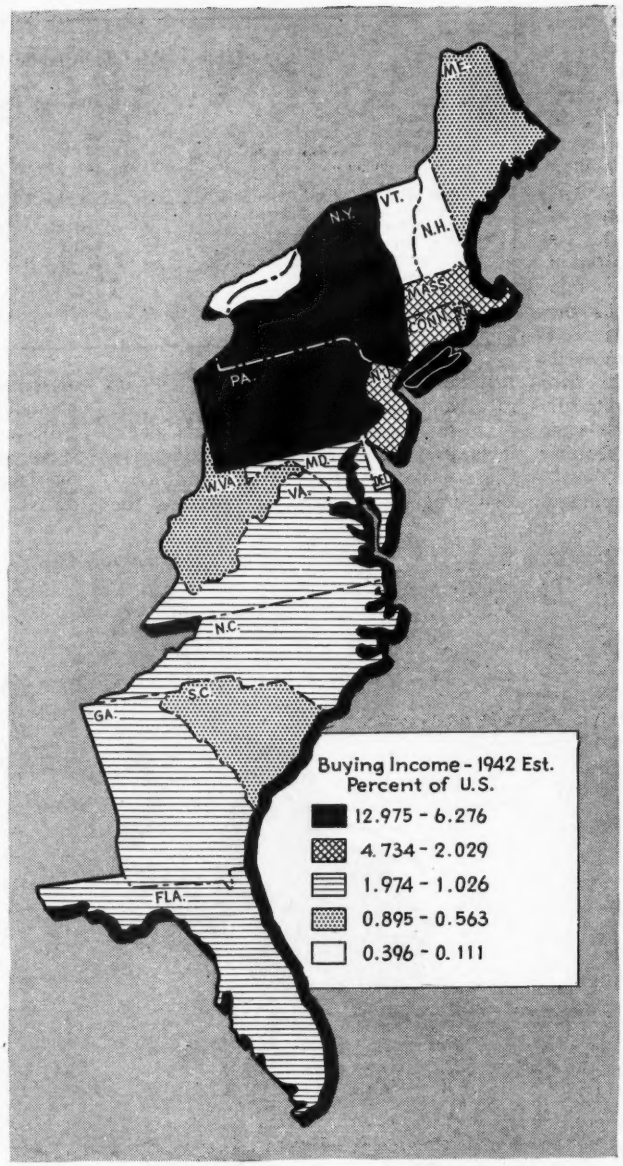
Due in no small measure to New York's large family population and buying power, Pennsylvania's high aviation-acceptance rating, and New Jersey's consistent comparative ratios, the Middle Atlantic Region ratings in the various market criteria add up a most important in the country as an aviation product distribution area.

"As Maine goes, so goes the nation" is an adage that holds true in aviation distribution measurements just about as it recently has in politics. For, in examining the New England Region—Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut—market ratings from Class A to Class E appear, as shown in Table II.

Maine's family population of 218,968 makes up but 0.6 percent of that of the United States, a ratio closely paralleled by its 0.67 percent of the national buying income. On retail sales, however, the ratio climbs slightly, being 0.75 percent of the country's total. Transportation needs are clearly shown by the 149,378 passenger autos owned, giving the state an average of 68 cars per hundred families.

As to past aviation acceptance, there are these indices: Maine's registration of aircraft on the last available date totaled 178, or 0.8 percent of the U. S. total, and 463 of the 90,603 non-airline pilots in continental United States were registered in the state. This smaller-than-average number of planes and pilots may be due in part to the fact that Maine's 28 airports—0.91 per 1,000 sq. mi.—comprised exactly 1 percent of those in the country.

The state's sparseness of airports is clear evidence that aviation has not received the same attention as have other transport means in the course of the state officials' excellent job of promoting Maine as a pleasure resort, and this same shortcoming is noted in many other states. While it is true that Maine's shoreline and comparatively large number of inland waters make the state well suited for water-based aircraft, the weather must be considered, for utility of this type of craft may well be limited to spring, summer, and fall months. Seasonal dealer and service operations, however,



Ranges of buying income—for which aircraft manufacturers, distributors, and dealers will have to compete against all comers—are shown for eastern portion of United States in this map covering New England, Middle-, and South Atlantic marketing regions. Here again, all three Middle Atlantic states are in two highest brackets, while New England and South Atlantic states embrace three.

Table II—New England Region

	Maine	New Hampshire	Vermont	Mass.	R. I.	Conn.	Total
1. Family pop.	218,968	132,936	92,435	1,120,694	187,706	448,682	2,201,421
2. Percent nat'l pop.	.6	.4	.2	3.2	.5	1.4	6.3
3. Percent U. S. buying income	.67	.32	.25	4.12	.71	2.20	8.27
4. Percent U. S. retail sales	.75	.38	.30	3.95	.79	2.22	8.38
5. No. passenger cars	149,378	97,508	67,971	766,929	151,558	405,904	1,639,248
6. No. cars per 100 families	68	73	74	68	81	91	75
7. No. aircraft registered	178	87	67	556	164	251	1,303
8. Percent aircraft registered	.8	.4	.3	2.4	.7	1.1	5.7
9. No. pilots registered	463	365	293	2,197	327	800	4,445
10. No. airports	28	15	12	52	7	25	139
11. Airports per 1,000 sq. mi.	.91	1.66	1.29	6.57	7.00	5.10	.....
12. Percent airports	1.0	.5	.5	1.7	.2	.9	4.8
13. State market rating	E	E	E	A	D	C	.....
14. Regional market rating	.....	.....	.....	.....	.....	.....	Seventh

might prove profitable in a New England distributorship.

Measured strictly on the basis of market criteria, however, Maine is ranked in Class E as an aviation merchandising area, standing in 42nd place among the 48 states.

New Hampshire, with a family population of 132, 936, or 0.4 percent of the U. S. total, has 0.32 percent of the buying income and does 0.38 percent of the retail sales. With 97,508 passenger cars owned within the state, it falls in the 73 cars-per-100-families bracket.

With but 87 aircraft registered, New Hampshire's percentage of the U.S. total stood at 0.4 percent, and non-airline pilots registered at the same time totaled 365. The state's 15 airports (1.66 per 1,000 sq. mi.) comprise 0.5 percent of those throughout the United States, but it has a goodly number of usable lakes which have long been popular for summer vacations. Deterring factors to increased use of aircraft on a year-round basis are the severe winters and the mountainous terrain found in a large part of the state.

On the basis of presently measurable market criteria alone, New Hampshire is gaged as a Class E aviation product market, standing in 45th place among the states.

Neighboring Vermont, with a family population of 92,435, or 0.2 percent of the national total, accounts for 0.25 percent of the buying income and 0.30 percent of the retail sales. Following in much the same ratio is automobile ownership, summing up to a total of 67,971 passenger cars.

This state's 67 aircraft comprise 0.3 percent of all those registered in the U. S., and 293 non-airline pilots were registered in New Hampshire. With 12 airports available, the state has 1.29 per 1,000 sq. mi., but there are a better-than-average number of water bodies for amphibious or float plane operations.

Here again, however, rugged terrain, which tends to bisect the state in a north-south direction, and severe winter weather both serve as deterrents to sizable expansion of personal flying in the immediate future. As in the case of New Hampshire, the limiting factors in the measurable data make Vermont a Class E market, standing at 48th in importance in the country.

Massachusetts is the highest ranking state of the New England region, being rated as a Class A aviation product market, and ninth most important in the country. It has 3.2 percent of the nation's family population, a total of 1,120,694 accounting for 4.12 percent of the buying income and 3.95 percent of the retail sales. Its automobile ownership, which amounts to 766,929, is more than twice that of Maine, New Hmapshire, and Vermont combined.

A total of 2,197 non-airline pilots were registered in this state, and the 556 aircraft tabulated comprised 2.4 percent of the national total. Its 52 airports—6.57 per 1,000 sq. mi.—account for 1.7 percent of those built throughout the country. Majority of these landing facilities are pretty well concentrated in the eastern portion of the state, following the concentration of population. Aside from the shoreline, Massachusetts has no considerable amount of facilities for water-based craft.

Economic factors which deserve special thought in any consideration of Massachusetts as a marketing area include the fact that the state is highly industrialized, being the site of a goodly share of the so-called "heavy" industries which have been subject to sharp fluctuations.

Rhode Island, 39th in importance on a nation-wide basis, is the only one of the New England states to fall in Class D, due in no small measure to its extremely small area. With 187,706 families, it has 0.5 percent of the nation's population and accounts for 0.71 percent of the buying income and 0.79 percent of the retail-sales. Its 151,558 passenger cars give it a high auto-ownership ratio second (as will be shown) only to that recorded by Connecticut.

Size of the state is emphasized by the fact that its 7 airports give it 7 per 1,000 sq. mi., a density exceeded only by New Jersey. Additionally, Narragansett Bay, with its many well protected harbors and thickly populated shoreline, deserves consideration for water-based operations.

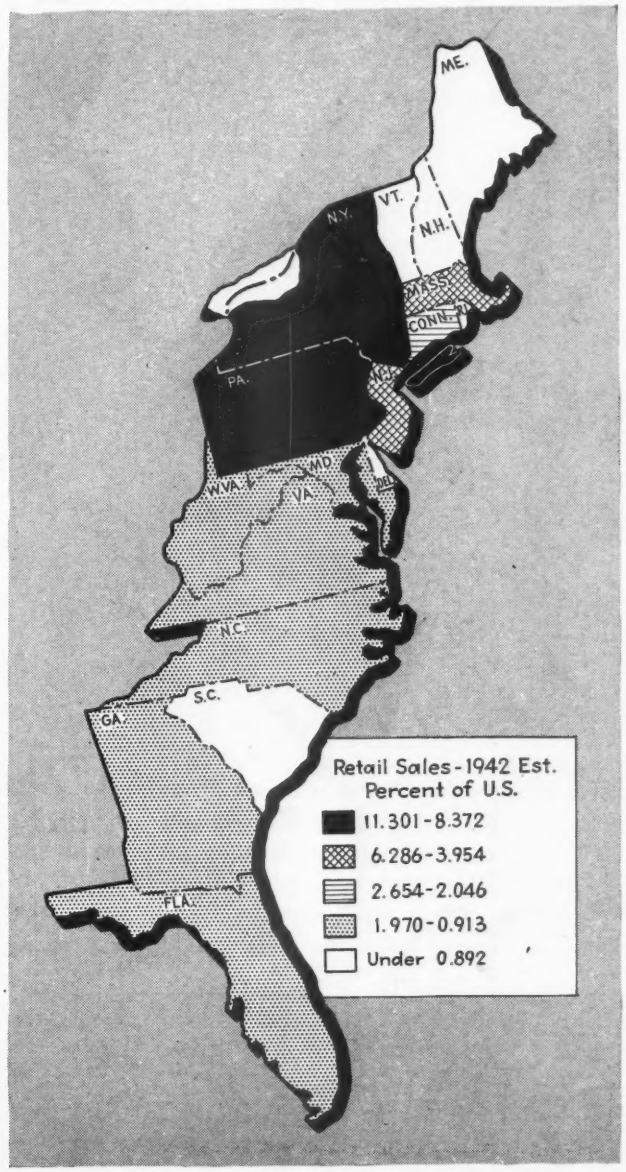
Connecticut's 488,682 families make up 1.4 percent of the national total, but the state has 2.20 percent of the buying income and accounts for almost exactly the same proportion of retail sales. As just indicated, it exceeds Rhode Island with its high ratio of automobile ownership, the total for the state standing at 405,904, or 91 per hundred families.

As for registered aircraft Connecticut has 251, or 1.1 percent, thus ranking second only to Massachusetts among the New England states in this respect. In the matter of airports it also compares well, for its 25 ports—0.9 percent—give it 5.1 ports per 1,000 sq. mi. Many small-boat harbors along its Long Island Sound shoreline are well adapted to water-based operations.

Accordingly, the airplane puts the entire state well within comfortable commuting distance to either New York or Boston. Recently a state commission published a booklet making a bid for post-war aviation development, stressing the availability of landing facilities and outlining future projects. However, one important factor must be carefully weighed in considering Connecticut as a market area: Statutes now on its books covering personal flying are among the most stringent in the nation.

Compilation of the measurable market criteria puts Connecticut in Class C, its individual rating among the states being 22nd.

Analysis of the data for the six states gives these guides for the New England Region:



Percentages of retail sales performance by various eastern states are shown here. Note close correlation of this criteria with data illustrated in other maps. These factors help give three Middle Atlantic states of New York, New Jersey, and Pennsylvania No. 1 rank among nine marketing regions in U. S., with New England standing seventh and South Atlantic fourth in importance.

A family population totaling 2,201,421 means this area has 6.3 percent of the families of the country representing 8.27 percent of the buying income and accounting for 8.38 percent of the retail sales. Ownership of 1,639,248 passenger autos shows that an average of 75 cars are owned per hundred families. The vast majority of these cars are concentrated in Massachusetts and Connecticut.

A total of 1,303, or 5.7 percent, aircraft were registered in New England, and 4,445 non-airline pilots lived there. The region's 139 airports comprised 4.8 percent of the national total.

On a weighted basis, the New England Region shapes up as the seventh most important of the country's nine regions.

South Atlantic

Moving below the Mason-Dixon Line into the South Atlantic states of Delaware, Maryland, Virginia, West Virginia, North and South Carolina, Georgia, and Florida, we find different problems of aviation product distribution. Greater areas must be covered to reach the same number of prospects but, by the same token, transportation needs are coming to favor the airplane. The terrain differs from that just considered, with the percentage of hilly or mountainous territory decreasing. The means of livelihood shows a basic change, from predominantly industrial to agricultural.

An exception to the generalization about distances being greater is afforded by Delaware, which in area is second smallest state in the union. With less than half the family population — 70,541 — recorded by Rhode Island (the one smaller state), Delaware has 0.2 percent of the family population and accounts for, respectively, 0.28 and 0.34 percent of the buying income and retail sales. And, with 57,009 passenger cars, Delaware again has less than half the number in the one smaller state.

On straight aviation indices it is also under Rhode Island, though not by so great a margin; for its 127 aircraft give it 0.6 percent of those in the country, and 249 non-airline pilots are registered there. Ten airports give the state 5.05 per 1,000 sq. mi.

Standing at 47th place among the states, Delaware measures out as a Class E market.

The adjacent state of Maryland has 465,683 families making up 1.3 percent of the U. S. total, and the figures for its percentage of buying income and retail sales are exactly the same, 1.97. With 328,700 passenger cars, Maryland is well above average for the region in the auto category.

In any market evaluation, the District of Columbia (whose area comes out of Maryland) must be considered either as a potential distributor-dealer location, or as a source of prospects for an outlet nearby. Wartime data on the D. of C.'s population, income, and retail sales would give an inaccurate picture, but on aviation these criteria give clues: According to reports on the last peacetime registration, the District had 287 registered aircraft, compared with 344 for the entire state of Maryland, and Washington's non-airline pilots (probably including CAA inspectors) totaled 728, against 1,053 in Maryland.

However, here is an important fact which must be kept in mind: If, as has been proposed in New York, the air space for 10 mi. around the major airline terminal is reserved for transport operations, there'll be little or no private flying in the District.

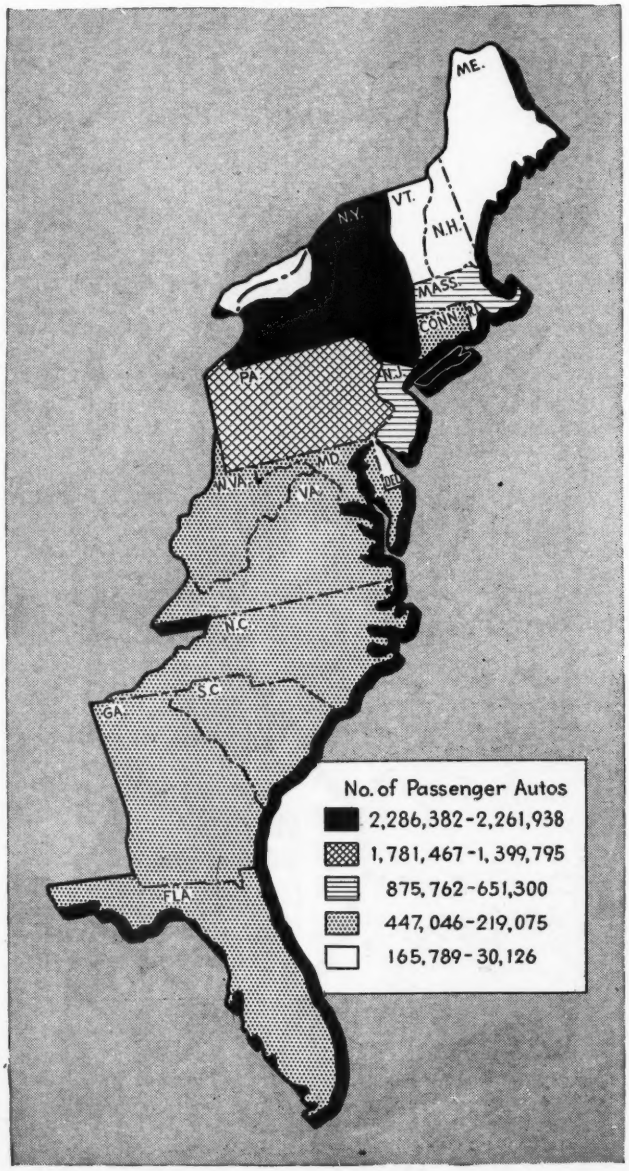
Measured entirely apart from the District of Columbia, Maryland is a Class C market, ranking 23rd among the 48 states.

Larger in area, and with consequent greater transportation needs, as is shown by 375,474 automobile registrations, is Virginia. Family population of 627,532 gives the state 1.8 percent of the country's total, but buying income and retail sales ratios are lower, both standing at 1.56 percent. Aviation criteria include the following: 1,410 pilots; 381, or 1.2 percent, aircraft; and 54 airports, or 1.35 per 1,000 sq. mi. It should be noted that the majority of airports are east and south of Appalachians (which parallel the northwest border of the state) and follow the more densely populated areas, being generally close to facilities for waterbased operations. Ranking 21st among the states, Virginia is a Class C market.

West Virginia, recording 1.5 percent of the family population with its total of 444,815, has 0.91 percent of the buying income, accounts for 0.93 percent of the retail sales, and owns 219,075 passenger autos. Latest compilations show the state had 966 non-airline pilots and 197, or 0.8 percent, of the aircraft. The 28 airports (1.16 per 1,000 sq. mi.) are mostly north and west of the Appalachians. The measurable data make West Virginia a Class D market, and on a weighted basis it ranks in 32nd place.

Though North Carolina is geographically larger than South Carolina and has a greater family population (789,659 compared with the latter's 434,968) the market ratings of the two are much closer, being Class B an C, respectively. Their respective state rankings on a weighted basis are 16th and 29th. Where North Carolina has 1.53 percent of the national buying income, South Carolina has .76 percent; where North C. does 1.59 percent of the retail sales, South C. does .89. With 463 aircraft, North's percentage is 1.9 against 214 and 0.9 percent for South.

On the matter of pilots, however, the difference is cut down, for North Carolina had 1,319 non-airline pilots registered and South Carolina had 975. And in flying facilities, too, the difference is smaller than state sizes would indicate, for where North Caro-



Clue to transportation needs and habits as a guide in establishing aviation product market areas is shown by passenger automobile ownership. New York's heavy population, of course, accounts in large measure for its lead in this respect. It is interesting to note consistency of auto ownership in eight South Atlantic states, averaging 57 cars per 100 families.

lina has 58 airports, or 1.18 per sq. mi., South Carolina has a total of 44, or 1.43 per sq. mi.

Georgia's 752,241 family population is equivalent to 2.2 percent of the American total, a predominantly rural group with 1.26 percent of the buying income, doing 1.42 percent of the retail sales, and owning 375,002 passenger autos. Aviation indices point to ready acceptance of flying, for 1,453 pilots were registered and the 339 aircraft comprised 1.4 percent of the nation's total. The 67 airports, equal to 1.15 per 1,000 sq. mi., are distributed about as even, geographically, as they could be. On the basis of measurable data, Georgia is the third of the South Atlantic Region's Class B markets, and its individual state rating weighs out at 18th place.

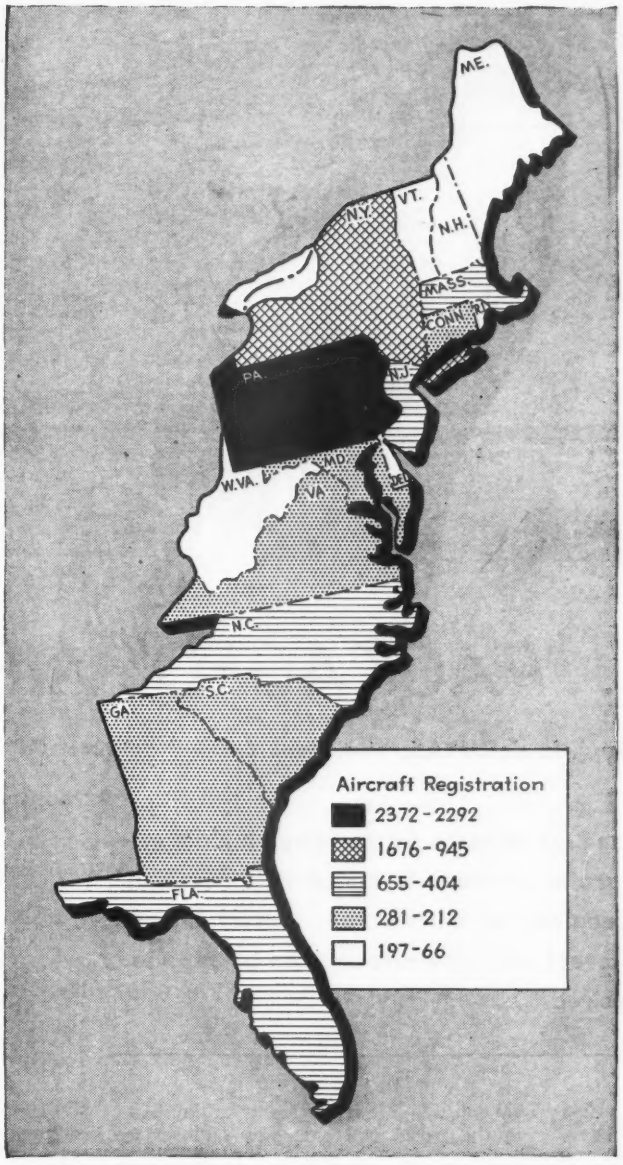
Florida, recording an unusually large "invasion" by money-laden tourists last winter, might best, for the sake of conservatism, be considered the exception rather than the rule; changing economic conditions might well mark a long lapse in such treks. Measured by a pre-boom criteria, the state stacks up as a Class B market area, ranking in 12th place on a state-by-state basis; for a family population of 519,987 puts it at 1.6 percent of the U. S. total and buying income and retail sales ratios are at 1.17 and 1.31 percent, respectively.

However, with 2,135 pilots and 528 registered aircraft, Florida led all seven of the other South Atlantic states as it also did with 145 airports, or 2.67 per 1,000 sq. mi.

Other important aviation criteria make Florida a state to watch carefully in formulating distribution plans. Since "it's a fer piece from anywhere to anywhere else" and weather conditions are generally as advertised, the airplane becomes an ideal transportation medium. The concentration of military flight training should have a double-barreled benefit; a network of landing fields (which may or may not be available for private flyers) has been built up, and the people who live in, and have visited Florida are used to seeing planes in the air. These people have been educated to the fact, perhaps subconsciously, that airplanes really fly. And if, as has been hopefully suggested, travel between the United States and Latin America increases to undreamed-of proportions, it must be remembered that Miami is the largest aviation port of entry for travelers headed South.

If Florida continues as the popular winter vacation land, there will be a corresponding effect upon seasonal operations, perhaps enough to be a dominant factor in selecting distribution locations.

As shown in Table III, the eight South Atlantic states' family population totals 4,278,771, or 12.3 percent of the national total, accounting for 9.25 percent of the buying income and a shade over 10 percent of the retail sales, and automobile ownership amounts to 2,428,118, or an average of 57 passenger cars per hundred families. With 2,872 planes, these states have 10.5 percent of the nation's registrations, and totals for non-airline pilots and airports stand at 9,560 and 426, respectively Based on a compilation of the data, the South Atlantic Region is the fourth most important market in the nation.



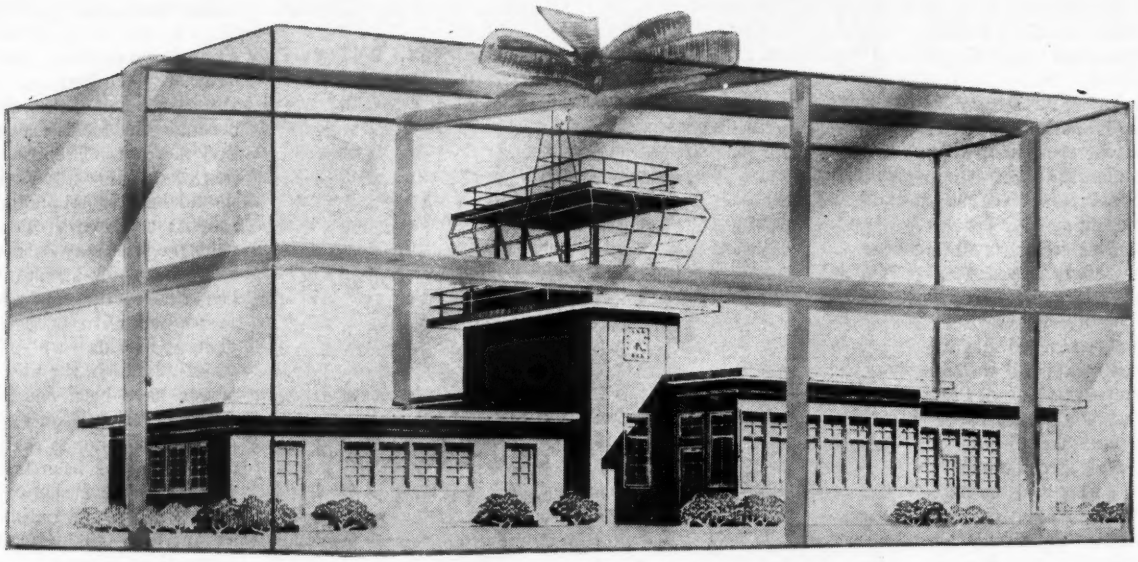
Index of aircraft registration finds Pennsylvania leading nation, for it had, on latest date for which information is available, 2,372 registered aircraft, topping second-place California's 2,292. Although three eastern marketing regions cover all five brackets for this criteria, there is still pretty consistent correlation with other marketing indices. Actual totals or percentages are shown in Tables I, II and III.

Table III—South Atlantic Region

	Delaware	*Maryland*	*Virginia*	*West Virginia*	*North Carolina*	*South Carolina*	*Georgia*	*Florida*	*Total*
1. Family pop.	70,541	465,683	627,532	444,815	789,659	434,968	752,241	519,887	4,278,771
2. Percent Nat'l pop.	2.	1.3	1.8	1.5	2.3	1.4	2.2	1.6	12.3
3. Percent U. S. buying income	.28	1.97	1.56	.91	1.53	.76	1.26	1.17	9.24
4. Percent U. S. retail sales	.34	1.97	1.56	.93	1.59	.89	1.42	1.31	10.01
5. No. passenger cars	57,009	328,700	375,474	219,075	447,046	246,321	375,002	379,491	2,428,118
6. No. cars per 100 families	82	71	60	49	56	56	50	73	57
7. No. aircraft registered	127	344*	381	197	463	214	339	528	2,872
8. Percent aircraft registered	.6	1.5	1.2	.8	1.9	.9	1.4	2.2	10.5
9. No. pilots	249	1,053**	1,410	966	1,319	975	1,453	2,135	9,560
10. No. airports	10	20	20	54	28	58	44	67	426
11. Airports per 1,000 sq. mi.	5.05	2.02	1.35	1.16	1.18	1.43	1.15	2.67	.....
12. Percent airports	.3	.6	1.8	1.0	1.9	1.5	2.4	4.9	14.4
13. State market rating	E	C	C	D	B	C	B	B	.....
14. Regional market rating	.....	.....	.....	.....	.....	.....	.....	.....	Fourth

*Exclusive of 287 in District of Columbia.
**Exclusive of 728 in District of Columbia

• Next month's article (Part II) will analyze the East North Central, East South Central, West North Central and West South Central regions. The concluding article (Part III), in addition to Mountain and Pacific Region analyses, will present a summary giving an over-all picture for the entire country, including a double-page map showing logical locations for major distribution points.



NOW . . . "PACKAGED" AIRPORTS

By J. L. deCUBAS, *Westinghouse Electric International Co.*

Everything from beacons and generators to terminal buildings—for tropic, temperate, or arctic service—is included in Westinghouse International's new engineered units . . . . Almost infinite number of combinations, to erect any type airport, can be supplied—and shipped by air if desired.

BOTH STUDIED FORECASTS and visionary predictions of commercial aviation's growth too often overlook one important axiom: That air transportation can develop only as far and as fast as adequate airports are available.

It is true that many countries have excellent systems of trunk line landing and service facilities, and the war has brought into being a worldwide network of military bases that may well have peacetime commercial utility for international trunk lines. But, in any realistic appraisal of air transport's usefulness, it must be said that any system will be only as good as its secondary and feeder airport facilities.

Trunk lines are undoubtedly the backbone of air transportation, but feeder operations—like the veins in the human body—are essential if air transport is to fully meet the economic needs of this or any other country. For air transportation to reach its full growth, a great number of new airports will have to be established, many of them in remote or hitherto inaccessible regions.

To meet the need for adequate, but at the same time economical, airports, Westinghouse Electric International Co. has developed "packaged airport equipment"—engineered and equipped units ready for shipping, by air if necessary, to any point in the world where landing and service facilities may be desired. It should be pointed out that no recommendations are made in our study on runway location, clearing, grading, drainage, etc., for these depend on land configuration, soil characteristics, availability of materials and labor, and other local factors.

In developing the packaged airport equipment, our engineers studied air transport requirements on a world-wide basis, finding that, irrespective of location or importance, every airport should have a minimum of equipment including radio communication, avigation aids, a source of electric energy, gasoline storage and pumping units, field lighting equipment, an administration building and, though not always essential but recommended, hangar facilities.

Moreover, depending upon local conditions and the size and functions of the airport, useful equipment may include the following: Water pumps and purification material, a sewage system, warehouses, living quarters, repair shops, and various services for handling traffic.

The requirements were studied on a functional basis in which the common elements were broken down into assemblies, each applying to some function or service of the airport. To provide the economies of standardization, yet give the greatest possible flexibility to meet climatic, geographic, and economic conditions, a total of 208 assemblies were developed. These, in turn, were consolidated into 41 "assembly sheets," each of which contains:

1. An identification code number.
2. Plans and schematic drawings of equipment and materials.
3. A list of items making up assembly.
4. General specifications and technical characteristics of materials and equipment.
5. Electrical connected load of electrical apparatus and water consumption data of different services.
6. Shipping weight of materials and equipment.

Meanwhile, equipment and materials for the airports have been grouped functionally as follows:

1. Generating and distribution equipment of various types and capacities: 29 assemblies, 4 assembly sheets.
2. Communication equipment and radio avigation devices: 16 assemblies, 3 assembly sheets.
3. Airport lighting equipment: 60 assemblies, 11 assembly sheets.
4. Meteorological equipment: 3 assemblies, 1 assembly sheet.
5. Miscellaneous field units: 6 assemblies, 1 assembly sheet.
6. Gasoline storage and fueling equipment: 6 assemblies, 1 assembly sheet.
7. Water storage, distribution and purification equipment: 7 assemblies, 2 assembly sheets.
8. Fire-fighting equipment: 4 assemblies, 1 assembly sheet.
9. Sewage disposal systems: 4 assemblies, 1 assembly sheet.

10. Buildings: 73 assemblies, 16 assembly sheets.

These standard assemblies can be applied to a specific airport plan, or to an airport layout identifiable with a specific problem, thus the selection of appropriate equipment will be a simple matter. A list of items which may be needed to set up a complete airport are shown in the accompanying Table I.

The contents of these assembly sheets are illustrated by assemblies covering the electrical generating and distribution equipment. In this equipment, for example, four capacities—50, 75, 100 and 150 kw.—are available, with an extra unit as standby to insure continuous service. The assembly sheet for this equipment includes a general description, specifications, and a general bill of materials which give all information from nominal capacity through necessary accessories to shipping weight. Even plan and three-view drawings showing proper installations are provided.

Considerable thought has been given to the electric system, for to operate efficiently and uninterruptedly, any airport must have a dependably maintained source of electrical energy and a rugged electrical distribution system. Primarily, every modern airport functions by the grace of electricity.

A thorough study of many installations, with due consideration of day and night factors and normal load diversity factors, has revealed that the average electrical load of the great majority of secondary airports will vary between 50 and 150 kw.

Two general types of electrical distribution systems are recommended: One for ports with a total average load up to 75 kw., with 3-phase, 4-wire low-voltage systems; and one for airports with total average load of over 75 kw., with 3-phase, 3-wire, 2,400-v. primary-distribution system.

Table I—Items to be Included in Westinghouse Packaged Airport Equipment

General descriptions, specifications, bills of materials, plans and installation drawings are provided for each assembly

Electrical generating equipment (4 capacities)
Electrical substations (4 capacities)
Distribution pole assemblies (High and low voltage)
Transformer bank assemblies (5 to 150 Kva.)
Runway contact lighting systems (1 to 4 runways of 2,000 to 12,000 ft. lengths)
Boundary lighting assemblies
Beacon tower assemblies (51 to 108 ft. high)
Field floodlight assemblies (1 to 4 runways)
Lighting control and signal assemblies
Miscellaneous airport lighting equipment
Radio transmitter and receivers
Telephone equipment
Public address systems
Meteorological equipment
Mobile field units (portable floodlights, crash trucks, fueling units, station wagon, snow plow)
Gasoline fueling systems (20 to 200 gal. per min. pumping capacities)
Water pumping, distribution and purification systems. (For 16 to 200 people.)
Fire fighting equipment
Sewage disposal systems
Pre-fabricated hangars (four types)
Machine tool equipment
Terminal buildings (four basic types, five variations of each)
Pre-fabricated power houses (10 variations)
Pump houses (5 variations)
Transmitter buildings (5 variations)
Pre-fabricated warehouse buildings (7 variations)
Pre-fabricated barracks buildings (5 variations)
Pre-fabricated guest house buildings (5 variations)
Pre-fabricated garage buildings (5 variations)

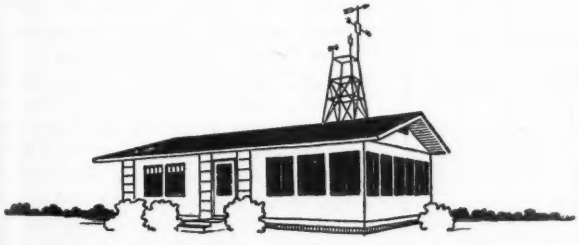
The generating assemblies used when electrical power is not available at the site of the airfield are based upon use of Diesel engine-generator units, since the fuel oil can be shipped to the fields in connection with gasoline for refueling aircraft. Moreover, Diesels are relatively light in weight, are rugged, and are easy to install and operate.

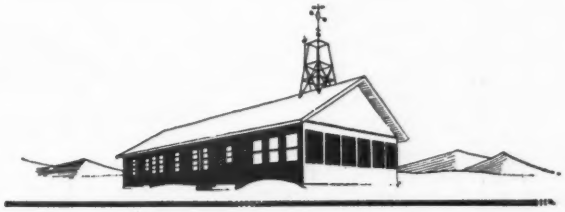
As part of the general description, detailed information is also provided for every other necessary item, from plumbing to complete hangars—for any or all of the items might be necessary, depending on location. A complete airport opening up new mining territory, for instance, might need everything on the list.

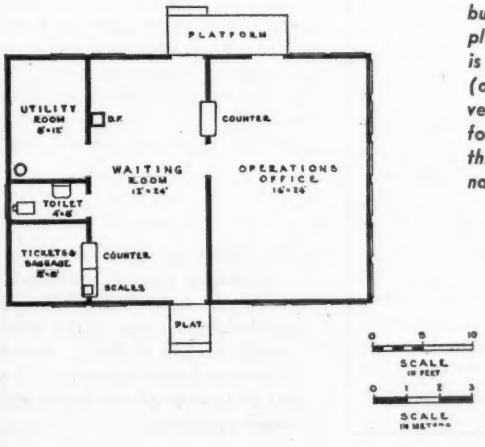
But for an airport located near electric power facilities the assemblies calling for generating equipment would be dropped and the one setting up a simple substation would be used. Naturally many of the items required for an airport are not of Westinghouse manufacture, but we are in touch with outstanding producers of such equipment so that the best of each type can be made available at the greatest possible economy consistent with quality.

In many cases climatic or geographic conditions will not affect efficiency of electric generating and distributing units, radio communications, airport lighting and meteorological equipment, mobile field units, fire-fighting units, gasoline fueling systems, and other such assemblies. So these are well standardized. However, where climate or geography would affect operations, specialized equipment is specified.

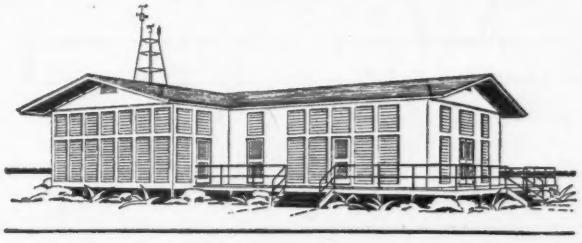
Among the buildings, four types of hangars are provided, ranging from a simple nose type to one "designed to provide shelter, storage, and repair facilities for airplanes up to a wing spread of 160 ft. and an over-all length of 200 ft."

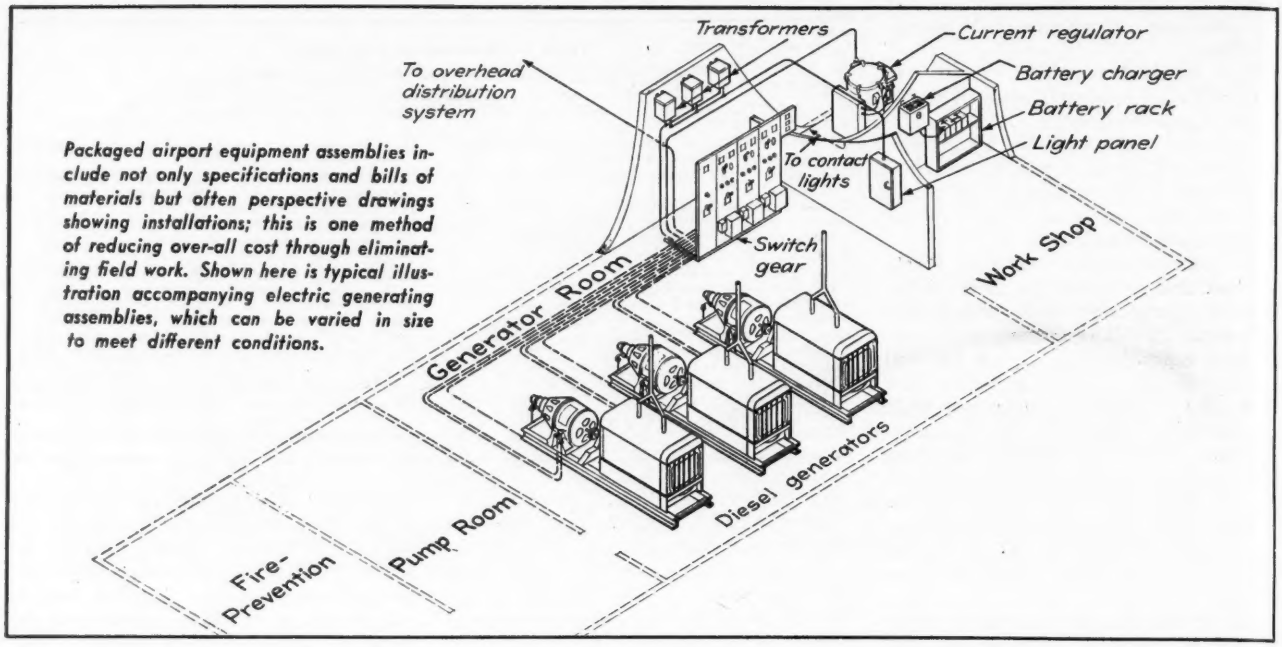




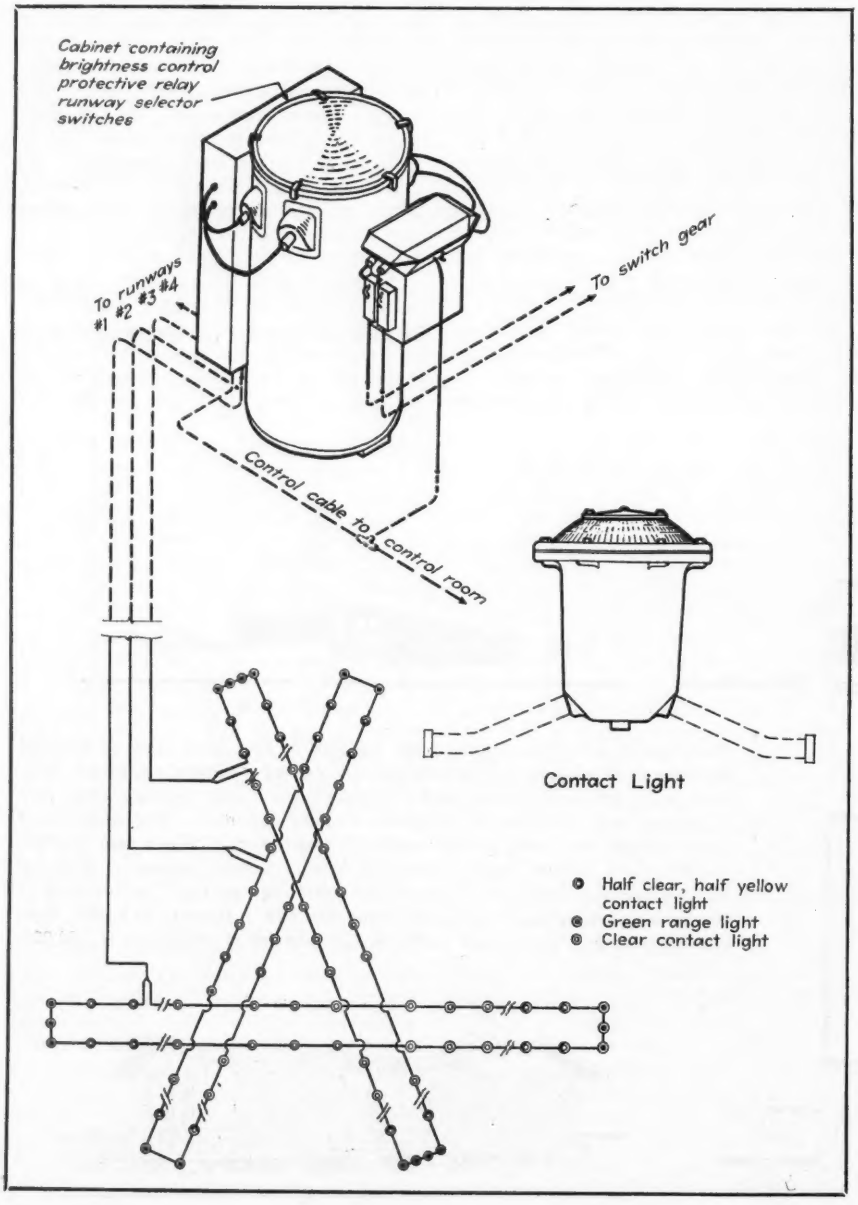


Variations to suit every condition are provided by four basic types of terminal buildings in Westinghouse International's new packaged airport equipment. Simplest type (left) is illustrated both in perspective and plan; example shown here is sloping roof variation for temperate climate operation. Next largest unit (above, right) has living quarters added to smallest unit. Shown here is arctic version. Third largest (below), depicted here in tropical version, is designed for uninterrupted traffic flow. Largest unit (shown in "package" in title-head of this article) is developed from third largest unit and is designed to handle international passenger and freight traffic through population centers up to 100,000.





Packaged airport equipment assemblies include not only specifications and bills of materials but often perspective drawings showing installations; this is one method of reducing over-all cost through eliminating field work. Shown here is typical illustration accompanying electric generating assemblies, which can be varied in size to meet different conditions.


Cabinet containing brightness control protective relay runway selector switches
To runways #1 #2 #3 #4
To switch gear
Control cable to control room
Contact Light
Half clear, half yellow contact light
Green range light
Clear contact light

This latter hangar can also house a machine shop, with two tool assemblies available, one with which "all but major airplane repairs may be effectively undertaken, the other with which general maintenance repair can be speedily carried out." A total of 20 terminal buildings are available—five variations for each of the four basic sizes. The smallest, or Type A terminal buildings, for instance, can be had with either flat or sloping roof and designed for temperate, tropical, or arctic climate. Consisting basically of an operations room housing radio, airport lighting control and meteorological equipment, and a passenger waiting room, Type A buildings are designed for very small feeder airports, private flying fields, hotels or resorts, meteorological stations, or remote operations such as lumber, mining, or oil developments.

The Type B terminal building is essentially a Type A structure with the addition of a wing for living quarters, consisting of two bedrooms, a living room, kitchen, and sanitary facilities. Like the Type A, from which it is developed, the Type B buildings are also suitable for remote localities, mining, lumbering or oil operations, military or trading posts, hotels and resorts, and shuttle services.

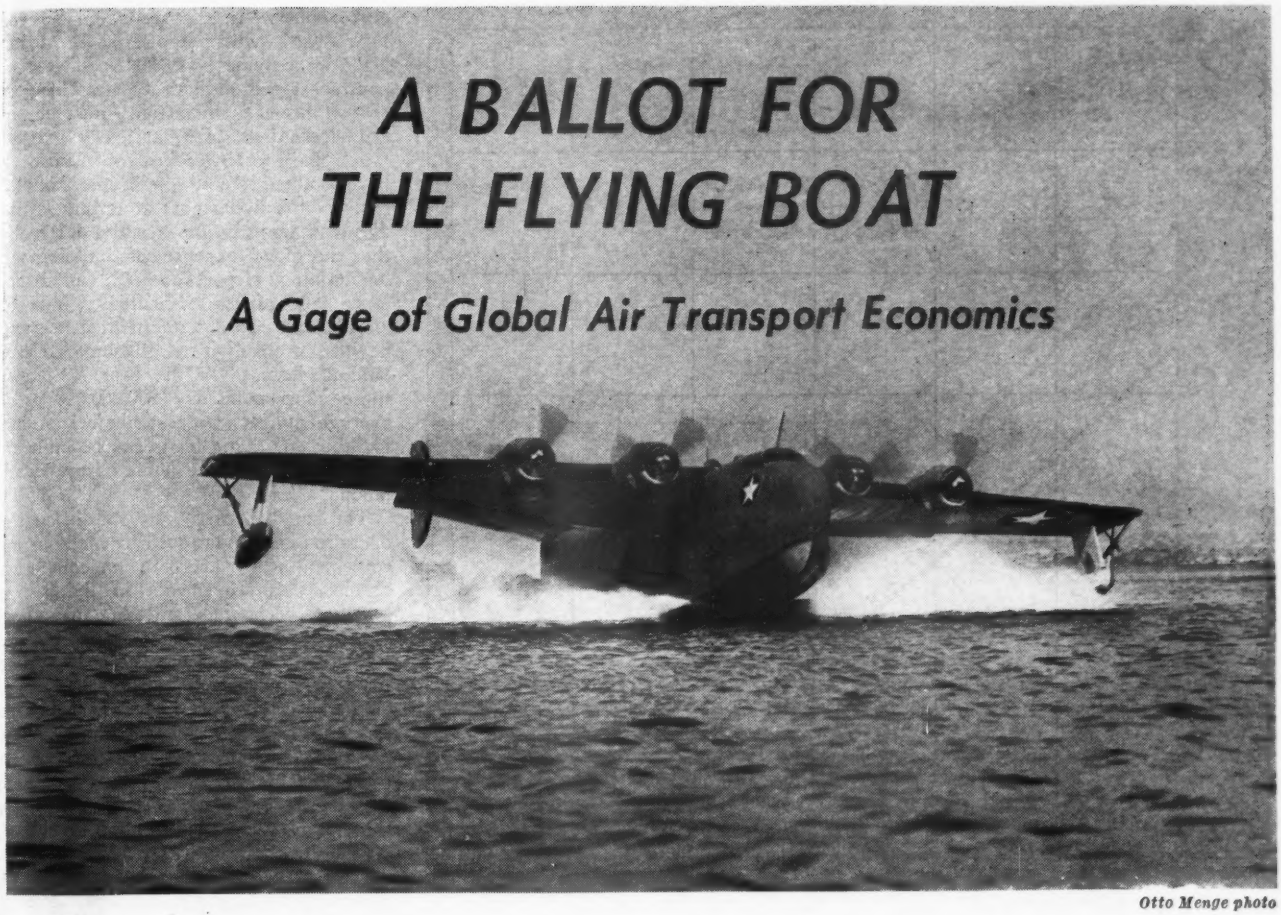
Type C buildings, for handling both freight and some passenger traffic, consist of a large lobby with related passenger services and an operations room. Like the other types, these buildings can be had with either flat or sloping roof for the three types of climatic conditions.

(*Turn to page* 253)

"Everything but the runways" is included in packaged airport equipment. Typical of details designed to simplify planning and installation work is this illustration of runway contact lighting. Assemblies are so arranged that equipment for any number of runways of any length may be "ordered by number."

A BALLOT FOR THE FLYING BOAT

A Gage of Global Air Transport Economics



Otto Menge photo

By CAPT. C. H. SCHILDHAUER, USNR

*Assistant Director for Plans and Logistics, Naval Air Transport Service**

Comparing speed, fuel-cargo ratios, ton-mile figures, terminal costs, maintenance, and other factors, the author contends that the flying boat boasts advantages over the land plane in the coming race for low cost international air transport.

AS AIR TRANSPORTATION comes of age, the controversy of land planes vs. flying boats for international operation promises to become one of the classic arguments of the postwar air world. And, as in the controversy of air-cooled vs. liquid-cooled engines, it begins to be apparent that this matter of contention will end in the realization that there is a continuing need for *both* types—that neither should be developed to the exclusion of the other.

Within the past decade and particularly during our war years, the landplane has been developed at a rapid pace. Backed by alert domestic airlines, Pearl Harbor found it in the fortunate position of being the one type of aircraft we were technically prepared to produce, particularly as a transport plane (there was no *transport* flying boat in production). The press of war dictated that it be given greater size and range for over-ocean flying.

Then once it was proven that land planes were safe for over-water travel, many members of the air industry accepted the "gospel" that the flying boat was out of the picture, not even bothering to investigate the situation. Such an attitude neglects consideration of the economics which, although submerged by the expediencies in pursuit of war, must inevitably come to the surface when peace is won and a cost-conscious industry takes the reins.

When the war is finally over, our air industry is going to be up to its neck in a complex competitive struggle for global business. In order that any airline may hold its own in the principal world markets for air transportation, equipment with a low operating cost will be a primary requisite. In the last analysis the type of equipment which will be used for any given operations will be determined by the dollar bill.

The most important factor is a fair comparison between the land plane and flying boat gaging their relative operating *cost per ton-mile.* In a struggle (the current war) where cost means nothing and speed means all, this element is widely neglected by land plane advocates. Related arguments (and ones of which land plane advocates have made much) are their comparative speed, terminal costs, and maintenance. We will present an analysis covering these factors, followed by an economic evaluation of a large high-altitude land plane and a large flying boat, both designed to meet the structural and performance requirements of government airworthiness regulations.

In the matter of *speed:* The aerodynamicist who says that the speed advantage of the large land plane over the flying boat will eliminate the latter from serious competition is (a) not a very good aerodynamicist, (b) unaware of the characteristics of the large flying boat, or (c) selling land planes. In the first place, the flying boat, in this regard, tends to improve steadily with size, to the extent that already at 160,000 lb., gross weight the flying boat will have a speed only 4 percent lower than that of a land plane of the same wing and power loading.

Under these circumstances one might ask if there will be many postwar travelers between, for example, New York and London, who will be willing to pay an "extra fare" just to get there 30

* Opinions expressed herein do not necessarily reflect the views of the Navy Department.

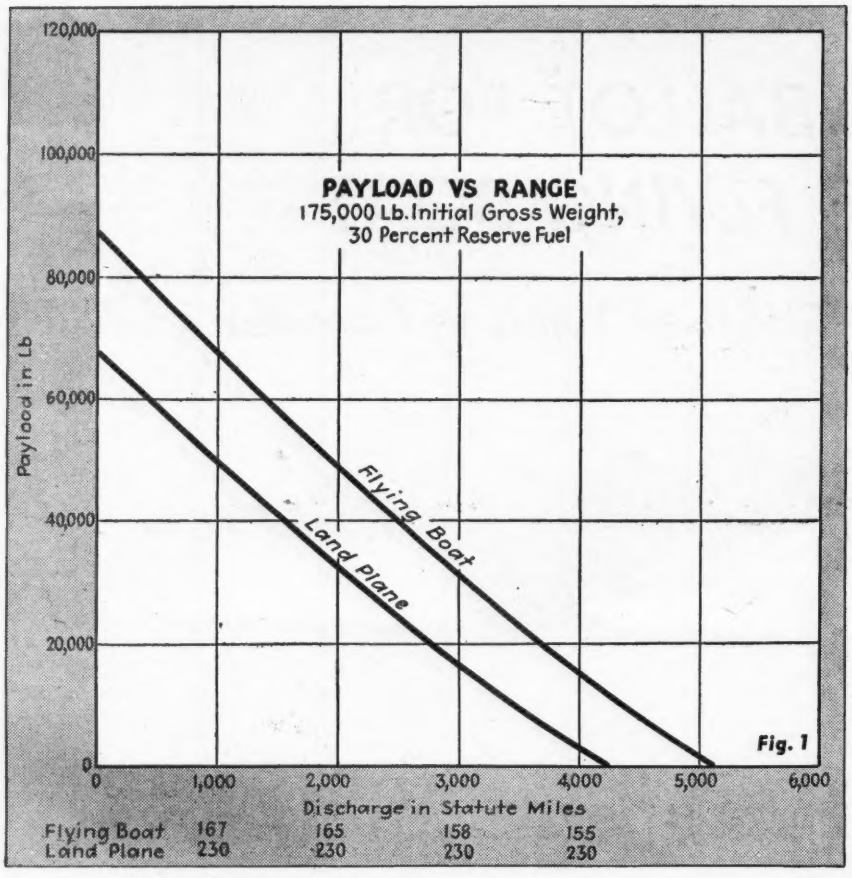


Fig. 1

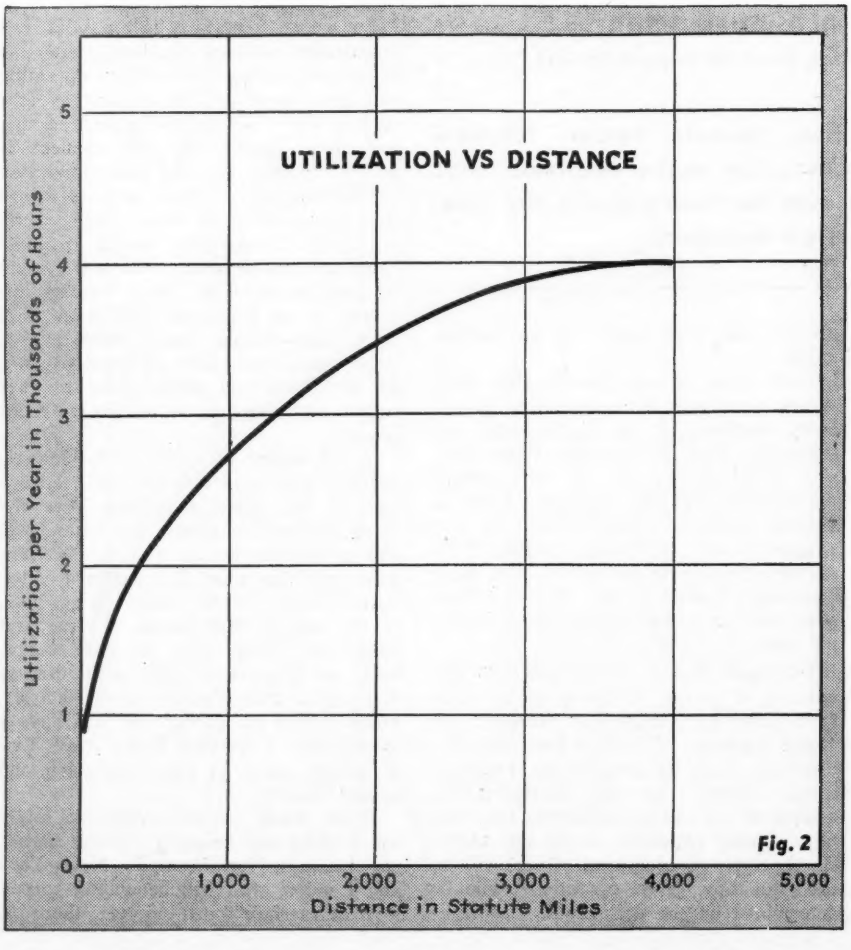


Fig. 2

min. sooner. In the second place, very high speed, whether offered in a land plane or a flying boat, is excessively expensive—speed in both types, where the cost of travel is important, must be subordinated to the load carried.

In regard to *terminal costs:* Those who have pointed out the extreme handling costs of the flying boat at terminals as a disadvantage have apparently overlooked the enormous expense of building and maintaining airports which can handle large land planes. Eventually both the airport first cost and its maintenance must be met, probably through some form of landing fees. For the cost of one of these superlandfields ($50,000,000 is an average figure), a great number of base facilities for flying boats can be built and maintained on the available natural water landing areas.

The handling of flying boats in current operations is handicapped by methods and equipment which are both inadequate and obsolete. Improvements in flying boat handling technique—still in an experimental status, although ready for development and subsequent use—indicate that the flying boat of the future will be handled with as little terminal time and manpower as the land plane.

As for *maintenance:* The problem of corrosion maintenance, which formerly engendered much disfavor for the flying boat, is now equalled, and probably exceeded, by the problems related with land plane's retractable landing gear and its complicated housing mechanism. Present designs indicate that large flying boats can be maintained with at least as much ease as equally large land planes.

Economic Evaluation

In arriving at the comparative cost-per-ton-mile of the flying boat and the land plane, three evaluations are made: 1. Performance, 2. utilization, and 3. comparison computation. Cost is a most representative yardstick, because most of the other common factors, such as fuel-cargo ratio, ton-miles-per-hour, etc., are evaluated while working through a cost analysis.

1. Performance. This is the "data required" step—the characteristics of each type together with:

A. Payload-vs.-range curve.

B. Average cruising speed for range.

Our Fig. 1 shows payload-vs.-range data plotted for two representative post-war commercial airplanes—for use in long range international operations, the large supercharged-cabin high-altitude land plane and the large flying boat, of the same gross weight. The cruising condition for each is that which will be used in operation for best all-around economy. The accuracy of these curves controls the accuracy of the result, and they must therefore be so drawn as to be acceptable to the person using the analysis. Most of the diverse ramifications of assumptions, such as optimum altitude and air speed, crew and equipment requirements, and cruising power, are removed from the computation proper.

2. Utilization. This step, summarized in Fig. 2, employs an arbitrary curve showing the increase in utilization with increasing flight lengths. It is a device which removes many troublesome variables from the computation—such as block speed vs. airspeed, handling time, etc.

3. Comparison Computation. The computation of direct flying costs is usually complicated by extravagant attempts toward accuracy. The following four short formulas present a clear, yet faithful, comparison of direct flying costs:

A. Fuel and oil

$$C_m = 3.1f$$

Where C_m = cost per mile, cents.
f = fuel and oil consumption, lb./mile (determined from payload curve).

This assumes a fuel cost of 17c. per gal. and oil cost of 50c. per gal., with fuel/oil ratio of 20:1, giving a resulting figure of 18.6c. per gal., or 3.1c. per lb.

B. Airplane depreciation.

$$C_m = \frac{C_a}{8\ U\ V}$$

Where C_a = cost of complete airplane.
V = true airspeed, mph.
U = utilization, hr./yr.

The constant, 8, assumes 8-yr. depreciation with no salvage value.

Cost of engines is included with that of the airplane; although engines will probably be surveyed before the end of the 8-yr. period, the cost of replacement will be handled as overhaul material..

C. Maintenance and servicing.

$$C_m = \frac{2.5\ W \times 275}{V}$$

Where W = weight of airplane empty (with engines). in tons.

Maintenance and servicing costs are the largest and most troublesome ones that the performance engineer is called upon to compute. The enormous variation shown by these costs in different operations has resulted in literally pages of formulas which attempt to reduce them to explicable denominators. Careful investigation, however, invariably reveals that the reason for this variation does not lie in incorrectly balanced formulas but instead actually begins right on the hangar floor where the aircraft are maintained. A survey of a number of widely different operations indicates that an aircraft in cargo transport operation can be maintained by approximately 2.5 man-hours per flying hour for each ton of weight empty.

The cost of the average man-hour ($2.75) was likewise obtained from a number of different operations. It is broken down as follows:

Material	$ .25
Labor	1.25
Overhead	1.25
	$2.75

Cost of overhaul of various components was not considered separately because there will be little difference for the land plane and flying boat, also because the proportion of such costs to the total is too small to warrant such treatment, particularly in view of the need for the simplification discussed above. Overhaul of an engine, for example, requires approximately 400 man-hours, and it must be performed at approximately 700-hr. intervals. So for a four-engine aircraft:

$$\frac{4 \times 400}{700} = 2.3 \text{ man-hours per flying hour.}$$

D. Crew pay cost.

$$C_m = \frac{P_1 + P_2 + P_3 \quad \ldots \quad \text{etc.} \times 100}{91.5V}$$

Where $P_1 P_2$, etc., are monthly salaries (dollars) of the crew members, based upon the following arbitrary figures:

Plane commander	$800
First officer	600
Second officer	500
First engineer	450
Second engineer	300
First avigator	400
Second avigator	300
First radio operator	350
Second radio operator	250
First steward	200
Second steward	150

Both large land planes and flying boats offering comparable passenger service and safety, and meeting Civil Aeronautics Administration requirements, will undoubtedly require a crew similar in number and type to the above. The 91.5 hr. per month is based upon a crew utilization of 1,100 hr. per year.

Miscellaneous individual items, such as crew expenses, interest on investment, insurance, and several like items, are not considered as such; however, the sum of these items will approximate 10 percent of the final cost, and the sum of other costs should be increased by the amount. Thus, total direct cost per ton-mile is:

$$C_m = 1.1\ C_m \text{ (fuel and oil)} + C_m \text{ (deprec.)} + \frac{C_m \text{ (maint.)} + C_m \text{ (crew pay)}}{L}$$

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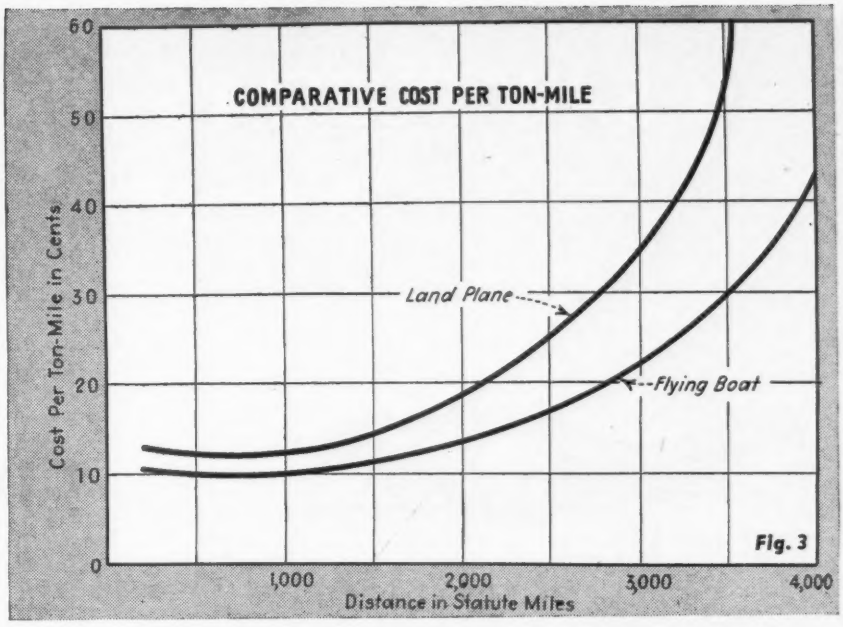


Fig. 3

Table I—Characteristics and Performance

	LAND PLANE Supercharged high altitude	FLYING BOAT
Gross weight	175,000 lb.	175,000 lb.
Basic weight	106,900 lb.	86,350 lb.
Fuel, oil, and cargo	68,100 lb.	88,650 lb.
Fuel, oil cargo/gross weight	38 percent	49.5 percent
Engines	4 x 3,000 hp. Turbo	4 x 3,000 hp. 1 Stage
Wing area, sq. ft.	3,430	3,900
Wing loading, lb/sq. ft.	51	45
Vel. max., sea level	256 mph.	218 mph.
Rate of climb at sea level	720 ft./min.	625 ft./min.
Operating altitude	25,000 Ft.	10,000 Ft.
Cost at $18.00 per lb	$1,925,000	$1,550,000

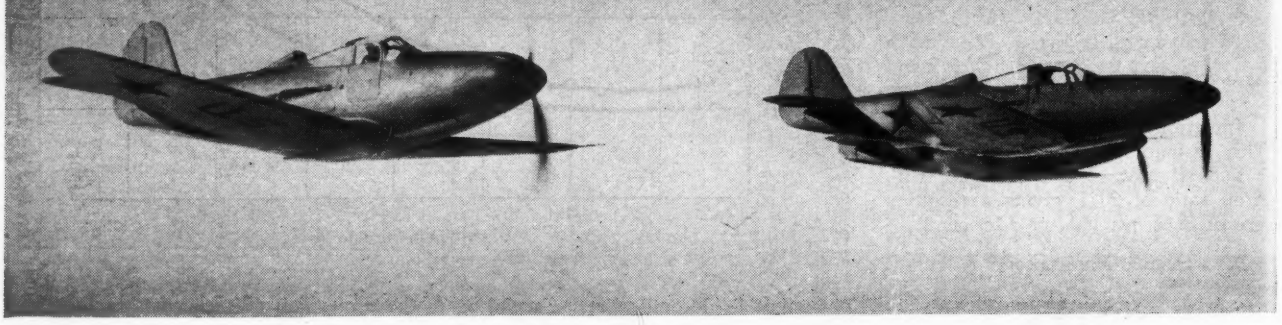
Performance (for maximum range condition plus 30% reserve fuel)

Range—1,000 Mi.	Land Plane	Flying Boat
Payload (lb.)	49,500	67,500
Time (hr.)	4.4	6.0
Average speed (mph.)	230	167
Altitude (ft.)	25,000	10,000
Range—2,000 Mi.		
Payload (lb.)	32,000	48,650
Time (hr.)	8.8	12.1
Average speed (mph.)	230	165
Altitude (ft.)	25,000	10,000

Range—3,000 Mi.	Land Plane	Flying Boat
Payload (lb.)	16,500	31,600
Time (hr.)	13.2	18.9
Average speed (mph.)	230	158
Altitude (ft.)	25,000	10,000
Range—4,000 Mi.		
Payload (lb.)	3,200	16,000
Time (hr.)	17.6	25.7
Average speed (mph.)	230	155
Altitude (ft.)	25,000	10,000

I SAW RUSSIA'S AIR POWER

By GEORGE D. RAY
Bell Aircraft Corp.



First hand report by an American aeronautical engineer on Russia's employment of American airplanes, on air fighting conditions on the Eastern Front, and on Russian-designed aircraft.

IN THE SPRING OF 1943, the writer was requested to accompany a technical mission to the U. S. S. R. as a representative of the Bell Aircraft Corp's engineering department. Our group arrived in Russia on Aug. 10 and remained for approximately four months. During our stay, our headquarters were in Moscow, where the writer was present at several meetings with the Technical Staff of the Red Air Forces, had an interview with a prominent Soviet designer, and visited a branch of the Central Aerodynamic & Hydrodynamic Institute. In addition, two trips were made by air—one from Moscow to a larger fighter base near the front line, the other to a large training center.

Purpose of our trip was to observe the *Airacobra* in action, to discuss any engineering and service problems that might have arisen in operation of the P-39 in Russia, and to learn what design improvements in the *Airacobra* and later Bell fighters seemed desirable in the light of Russian experience.

The Bell P-39 fighter was first sent to Russia as a result of a Lease-Lend transfer from England of a relatively small number of airplanes. These planes were assembled and flown at a base near Moscow in the winter of 1941-1942. We were introduced to some of the Russian officers who had directed this work and were told some of their early experiences. It is to the credit of the Red Air Forces technical staff and to the designers of the airplane that no serious difficulties were encountered, although it was not possible at that time for a Bell representative to be present. In fact, until last spring no Bell or Allison representative had visited the U. S. S. R., although many P-39's and Allison engines were in use.

We found that the *Airacobra* was performing very well as a short-range fighter at medium altitudes, although at times it is used for other purposes. Usually Russian attack airplanes are employed for strafing and low-level bombing attacks, rather than fighters.

As a Russian fighter, the P-39 is lightened by omitting the wing guns and by

Bell engineers who were on the Russian mission talk it over with Pres. Larry Bell. Left to right: William R. Hawkins, Leighton W. Rogers, Lawrence D. Bell, Francis J. Ziombeck, and Author George D. Ray.

using somewhat less radio than is installed at the Bell factory. Certain modifications were necessary at first for earlier P-39 models because of the rigors of winter on some parts of the front, but most of these are now incorporated into the airplane's design.

In most respects, however, the P-39 as operated in Russia is identical with its sister ships in the South Pacific and other American war theaters. The original paint is altered only by replacing the American insignia with the Red Star, and the original decalcomanias which locate points for servicing operations and items of equipment are permitted to remain in English, even though at first sight they must be as confusing to the Russian mechanics as even the most familiar words were to us when written in the Russian alphabet.

The huge task of translating service literature from English to Russian is carried out continuously by technicians of the Red Air Forces. While the translation of the rapidly changing terms of our technical aeronautical language into any other language is always quite exacting, we found that once the alphabet is learned, the Russian language is not quite so formidable as it at first appears.

The *Airacobra's* record in combats with German fighters, dive-bombers, and medium bombers is very good, some *Airacobra* pilots having as many as 30 victories to their credit. For the most part, fighting conditions vary from those encountered in North Africa, Italy, and the South Pacific in that the country is quite level, which permits installing airfields close to the front lines, so that operations rarely require the use of auxiliary fuel tanks. It is thus more frequently possible for the pilot to land back of his own front lines in spite of severe damage to airplane structure or power plant.

Combats usually take place at altitudes of 15,000 ft. or less, rather than at the extreme altitudes sometimes required in other theaters. It is charactertistic of the fighting in Russia that comparatively little long-range strategic bombing has been carried out by either side.

The Stormovik is a purely Russian product. It has no American counterpart. (Preslit-Sovfoto photo.)

Russian airplane production is concentrated chiefly upon single-engine fighters, such as the Yak-9 and LA-5; twin-engine dive-bombers and medium bombers, such as the PE-2 and DB-3; the well-known single engined *Stormovik* attack airplane; and military versions of the Douglas DC-3.

Although the bulk of Russian-operated airplanes are Russian built, these have been supplemented by American planes which are of similar types, except that the *Stormovik* has no close American counterpart. They are operated in Russia without the help of American technicians, other than for several brief visits by technical advisors.

An excellent opportunity to see several modern Russian fighters and the PE-2 dive-bomber at close range and to compare them with Allied and enemy types was afforded the writer at a branch of the Central Aerodynamic & Hydrodynamic Institute, which is in many respects a counterpart of our NACA.

This exhibit is permanent and intended to acquaint Russian aeronautcal designers with arrangements, mechanisms, and methods of constructon which are used by others. To make the interior details easier to see, much of the wing and fuselage covering material is removed on one side of the aircraft's plane of symmetry.

At the exhibit, undesirable as well as desirable characteristics are indicated, such as units which are installed so that they are difficult to service or remove. It was the writer's impression that the Russian airplanes were simplest, the German airplanes were best designed for servicing, and that American airplanes, characteristically, contained the most radio equipment, the best heaters and avigation instruments, and were better adapted to a wide range of operating conditions.

Russian airplanes, particularly the *Stormovik* and fighter types, employ wooden plastic bonded construction extensively, or mixed wood, duraluminum, and steel structures. The most notable example of mixed construction is the Yak-9, which has wooden wing covering and ribs, steel and duralumin spars, a steel tube fuselage, and duralumin tail surfaces.

Russian fighter types employ cannon and heavy machine guns mounted near the centerline of the airplane, and they are comparatively lightly armed and armored. Their low weight-to-power ratios result in good rates of climb, while their top speed is approximately the same as that of opposing enemy fighters. As noted above, Russian fighters are comparatively unencumbered by radio equipment, blind flying equipment, elaborate starting systems, heaters, life rafts, etc. Wing loadings and landing speeds are about the same as those of American fighters.

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The Yak-9, one of the newer fighters of the Soviet Air Force.

Keying Market Research To the Aircraft Industry

By **E. E. LOTHROP,** *Manager, Research & Statistical Dept., Aeronautical Chamber of Commerce*

Outlining the steps necessary for planning adequate long-range merchandising, the author points to the need for a comprehensive program triply aimed at three major outlets.

THE AIRCRAFT INDUSTRY has three basic markets—military, transport, and private—which will govern the volume of postwar production. Of these markets, the first two can be subdivided as follows: Military into domestic and export; and transport into airline (both domestic and foreign), fixed base or charter outlets, and private corporation operations.

While economists agree that the postwar period will be one of intense competition in all lines, for the aircraft industry it will be particularly intense because of greatly expanded production capacity, political pressure to use that capacity, development of new planes, and the desire to employ as many returning servicemen as possible.

If it is thus true—as seems evident from every angle—that aviation will have its biggest competitive struggle in a cutback market, it follows that the organization which will maintain or improve its position will be that which combines improved design and low-cost production with effective marketing. Intelligent use of marketing procedures may, in fact, spell the difference between success or failure.

While winning the war is today paramount, effective marketing cannot be left untouched too long; such programs can no more be turned on at a moment's notice than can production schedules. Moreover, market planning is of value right now for, properly publicized, such efforts can nullify the restless uncertainty of workers whose most persistent question is, "Will I have a job after the war?" Such planning will require even more flexible thinking than has been necessary, it will require consideration of many more problems, and it will require thinking further ahead.

Re-conversion from war to peacetime production is, in large part, a marketing problem, in which the first step is to calculate how the markets may be affected by estimated postwar incomes and total business volume. This calculation will involve an appraisal of accumulated demand of the transport and private aviation markets at the end of the war and will also necessitate analysis of the effect of war-born improvements in planes as well as possible changes in distribution methods or price policies.

The market potential accompanying high incomes, deferred demand, and accumulated purchasing power must, then, be translated into an effective demand for the aircraft industry. This, in turn, calls for more, rather than less, sales and advertising effort.

If aviation is to maintain a large part of its present organization, its current business volume and corresponding place as the nation's No. 1 industry, it must be prepared to market in ways which are relatively foreign to present operations. The natural tendency would be for manufacturers to seek those lines in which they can make most effective use of demonstrated technical engineering and production skills, but this would require distribution through unfamiliar channels, and to a completely different type of market. It would also mean breaking into a field where it is essential to have dealer organization and ability to distribute costs of promotion and other overhead over a limited volume.

Looking further into the future, those concerned with aviation markets must face the fact that accumulated demand for transport and private planes will be relatively small in comparison with existing production facilities. This apparently leaves the alternatives of expanding this market as far as possible by such means as rapid obsolescence or "dynamic" pricing.

Finding the answers to these problems requires market research which, to be effective, must be private research, since cooperative research is like asking an outsider to look at one's watch to see what time it is. For the aircraft industry there are two basic answers to be found: First, what planes can be sold, and, second, how many will the market absorb?

In the military market particularly, consideration must be given to what the war itself is doing to change many conditions on which prewar estimates were based. The extent to which production has been geared up to meet war demands has drastically altered all ideas of volume, so much so that output can be many times greater than demand. Due allowance, however, should be made for the fact the United States undoubtedly will maintain a regular Army and Navy of about 2,000,000 men for police purposes; the job of properly supplying such a military force will in itself be no mean market.

The ultimate military market will depend on five principal factors: First, length and severity of the war and, as a related factor, the number of planes surviving hostilities; second, decisiveness of the victory and peace terms; third, the role of the United States in international policing; fourth, new developments in military aircraft and the resulting obsolescence rate for existing craft; and fifth, public and Congressional reaction toward continued military spending.

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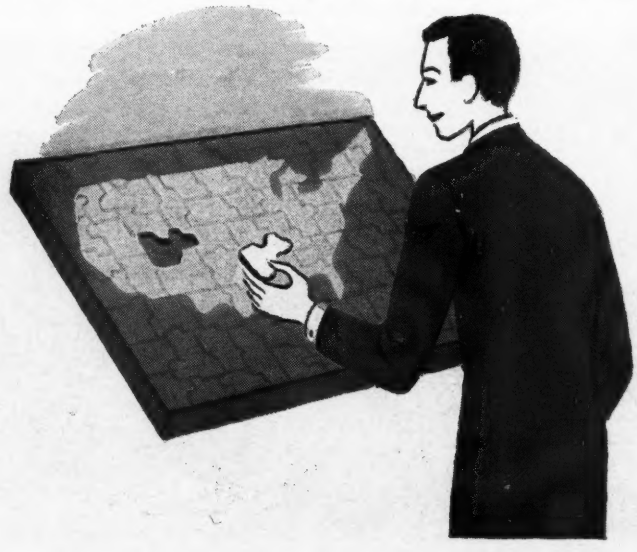


Side Slips

JUST READ an intriguing story of a Dane's escape to England in a small prewar training plane, detailing the vicissitudes of readying the craft and securing—under the Gestapo's nose—fuel for the over-water hop. One line in the story, though, completely baffles our engineering friends. "To prevent the Germans from detecting the plane," it said, "the exhaust pipe was camouflaged."

• They call one avigator "Purple Heart Johnny," but it's usually redfaced Johnny at a mention of his nickname. He'd gotten his plane over the target and had made a good run, then just as the plane got on course for home the flak got thick and close. Suddenly he felt a stabbing pain in the back of his lap, and he quickly reported over the inter-com that he was wounded. His crew mates made him comfortable and kept him quiet; the pilot radio'd ahead to the base to have an ambulance waiting.

As soon as they'd landed, the surgeon started his examination and found the "wound." It had been caused by the opening of the big safety pin which "Purple Heart" used to hold up the baggy part of his wool underwear.

• Aircraft recognition is a study which apparently still hasn't been mastered by the masses. The other day, for instance, three young Navy ferry pilots delivering *Wildcats*—via a circuitous route—buzzed New York and rat-raced around the Empire State Building at about the 29th floor. Calls to the police and newspapers from frightened, indignant, or amused citizens had everything from one to six planes involved, and the types reported ran from "army planes" to "a Jap *Zero*."

• The young fighter squadron colonel's first flight in a B-26 was as pilot, and needless to say, he learned a lot while falling in love with the ship. Since the flight was a long over-water hop, he was a touch tired after making his first landing. Not too tired, though, to agree that the visiting brigadier general could have a flight—also to be the b.g.'s first in that type of craft. In fact the general would act as co-pilot.

With his first takeoff still a vivid memory, the colonel vaguely remembered reading or hearing someplace that the way to get a B-26 in the air was to hold the nose down till you had plenty of speed, then haul back on the wheel. Anyway that's what he tried. But as the ground speed went up, the pressure on the control column got greater—he was pushing with all his might to keep it forward.

Finally he sneaked a look to see "what gave" with his be-starred co-pilot. "Imagine," he reports, "there the guy sat with his feet braced against the instrument panel, pullin' back till I thought he'd bust. I just relaxed, and brother we really took off."

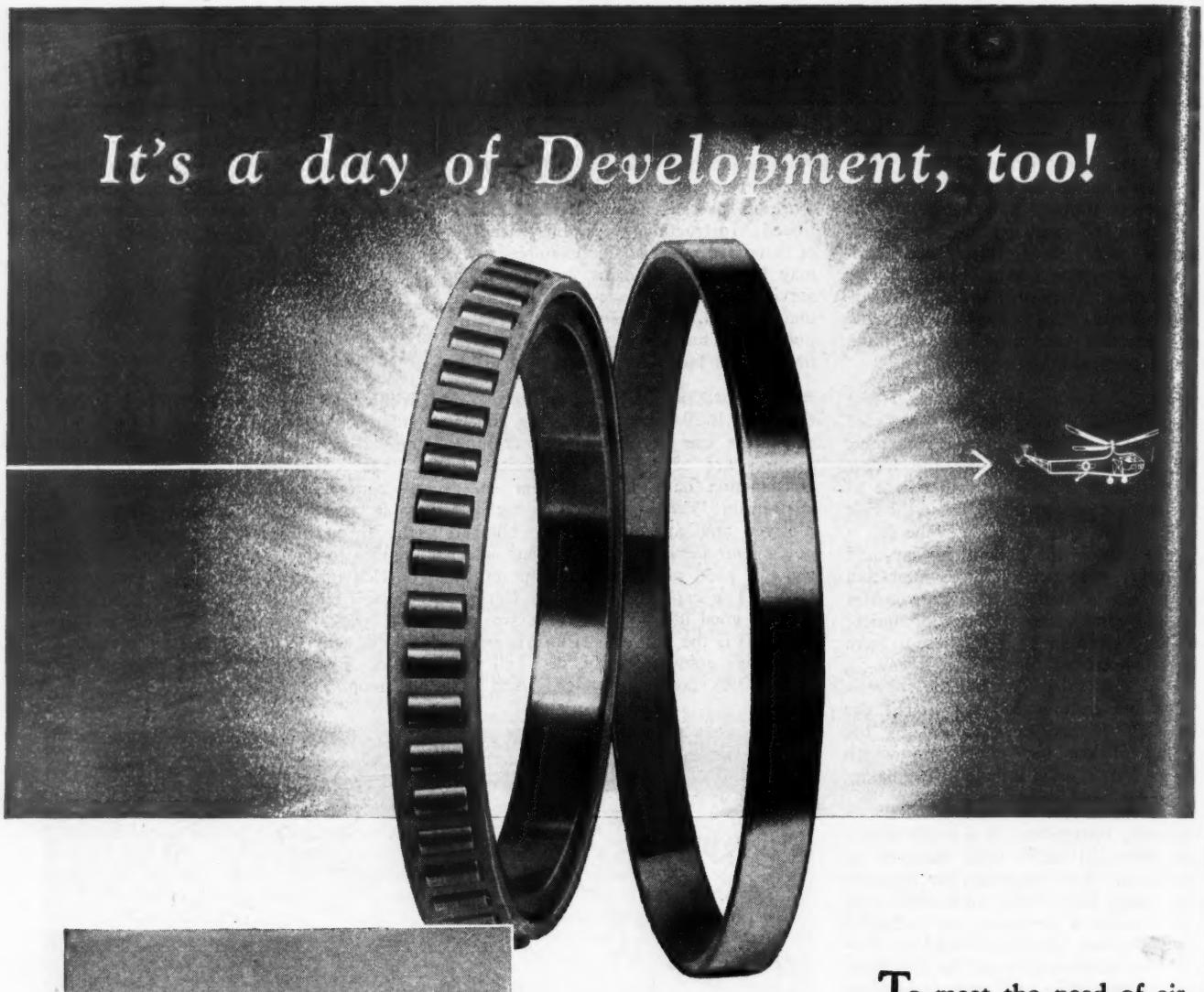
• It's wonderful to know how the armed forces trust the press, how the average working pressman's loyalty is unquestioned: Instructions regarding handling of restricted material, for example, say it may be read by anyone in government service and civilians whose loyalty is unquestioned, "but *never the press or public.*" (The italics are ours, but the instructions had it in bold-face type.)

• The most beautiful case history concerns the B-29—about which the American press can say practically nothing; pictures are *verboten*, performance and construction data must be kept super-hush-hush. Yet, in addition to high explosives and incendiaries, our bombers going over Germany drop leaflets which show a good accurate silhouette of the B-29. The caption, written in German, gives a good idea of the craft's size and says this is the new American *Superfortress* that's going to really raise hell with you if you don't surrender. And still "public relations" officers wonder why working reporters hesitate to salaam as they repeat "you must not say anything that will give aid or comfort to the enemy."

• Watching some expert parachute packers at work the other day reminded us of the time, some 20 yrs. ago, when we assisted at a repacking. A barnstormer, fellow who'd shifted to chute jumping from rodeo bronc riding—which he considered too dangerous—had made a successful jump and passed the hat to collect $19.45. We went into an abandoned restaurant to use the counter as a packing table, there going to work carefully on the shroud lines and outer folds. But getting to the final stage, which involved a trick folding of the "lobe" part of the Russell chute, he *crammed* the silk into the pack, drawling, "There's a very special way to do this, but I don't pay no heed. Thing always seems to open when I jump."

Old man Maguire WOULD try jet propulsion.

It's a day of Development, too!



* *A Sikorsky XR-4 hovering motionless over East Hartford, Connecticut. This first helicopter to be delivered to the Army Air Forces is equipped with six Timken Bearings in the Main Rotor Blade, two in the Tail Rotor Gear Box, and six in the wheels.*

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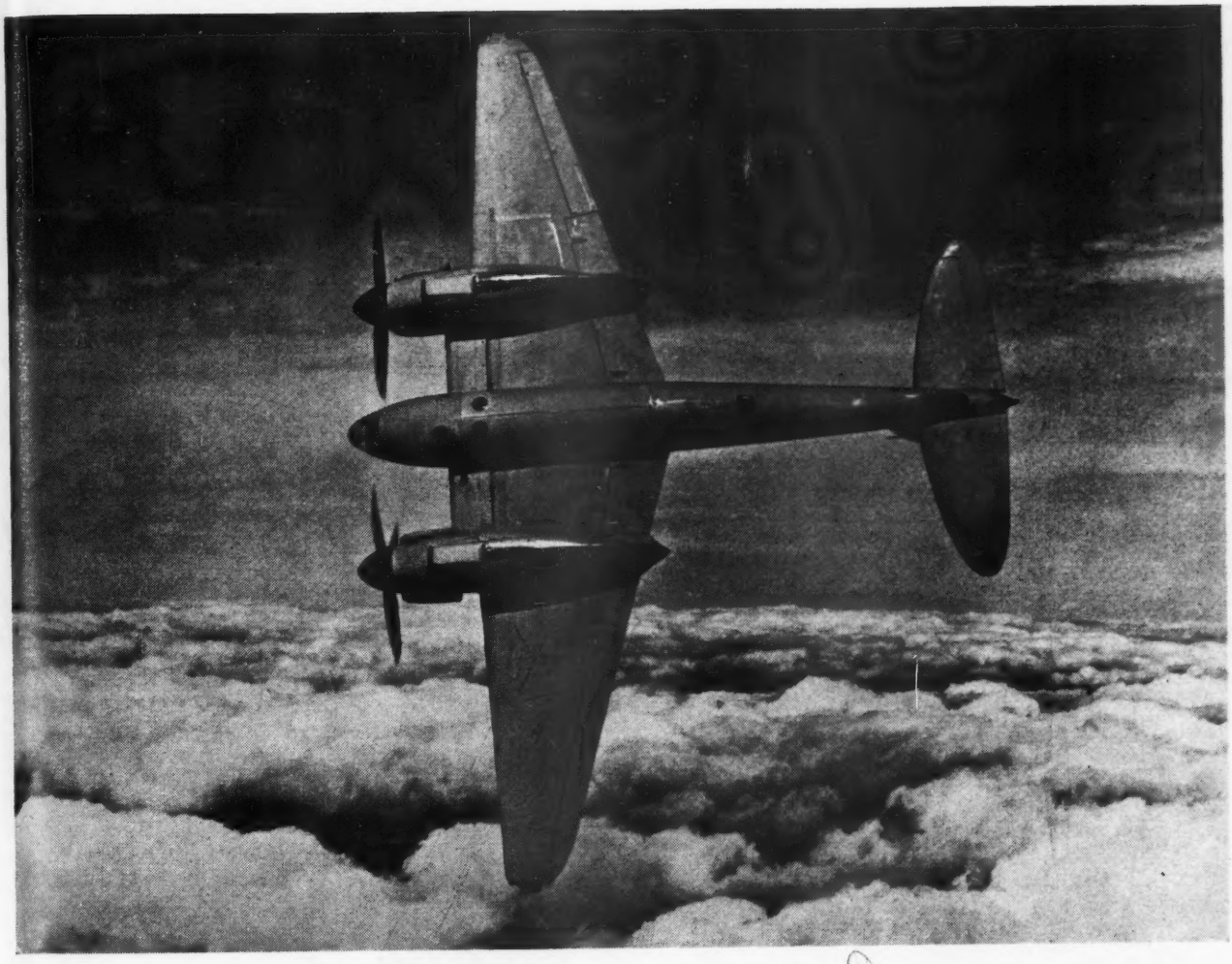
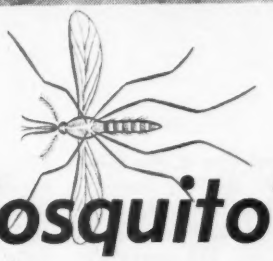


DESIGN ANALYSIS NO. 6



DeHavilland "Mosquito"

PART I

By CHESTER S. RICKER, *Detroit Editor, "Aviation"*

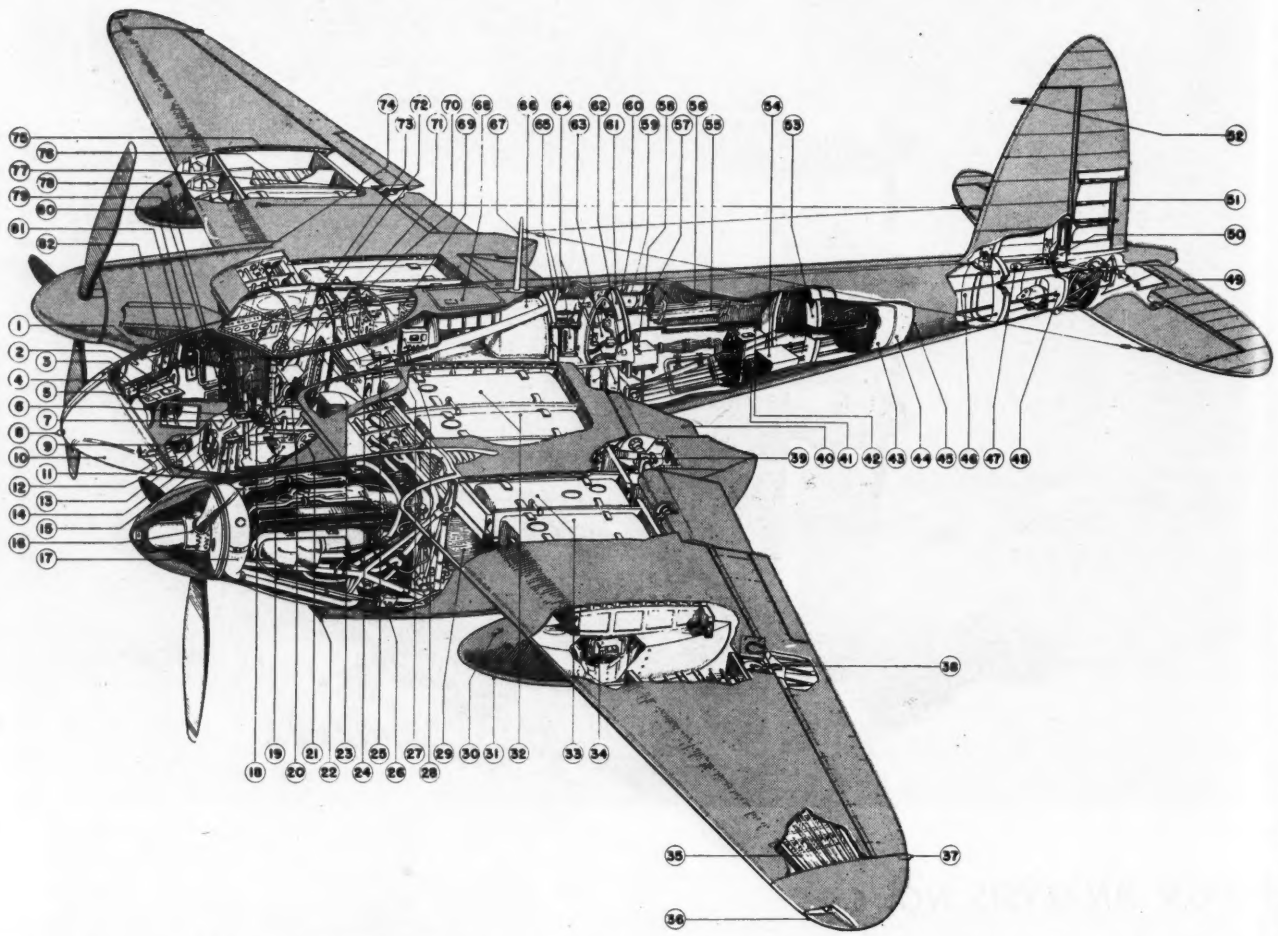
Continuing Aviation's comprehensive series, deHavilland's famous all-wood fighter-bomber is torn down to design and construction fundamentals, revealing unusual thought and execution . . . First of a graphic two-part study.

ALTHOUGH the *Mosquito* performances make newspaper headlines almost every day, the background of unusual design which produced this airplane is not common knowledge. Neither are the details of its advanced all-wood construction, which is the culmination of 23 yr. of deHavilland experience in wooden aircraft. It is of interest here to note that during this time all DH designs except one have been in wood.

The ideas of Sir Geoffrey deHavilland and C. C. Walker, director and chief engineer, were presented to the British Air Ministry in Sept. 1939. Their aims were to create a wooden operational aircraft to increase air force strength without further strain on the metal industries, also to sacrifice armament for greater bomber speed.

The design was immediately begun, and in Dec. 1939 a layout was presented which has not yet been fundamentally changed—a twin-*Merlin*-engine two-man crew wooden bomber without armament, carrying a 3,000-lb. bomb load and having a 1,500-mi. range at fighter speed.

In spite of the fact that the company was rapidly expanding production of *Tiger Moths* and *Oxfords* for training purposes, once the *Mosquito* was proposed production was immediately started on the *Mosquito* prototype—the company's 98th design. Only 29 months after the design layout was completed, a full squadron bombed Cologne—on May 30, 1942.



Upper and lower sectional view of Mosquito. References: (1) Fireman's axe; (2) bombardier's elbow pad; (3) inter-com.; (4) portable oxygen bottle; (5) bombardier's writing pad; (6) pilot's compass; (7) parachute stowage; (8) navigation headlight; (9) bombsight; (10) bombardier's window; (11) impact switch; (12) Plexiglas nose; (13) gravity switch; (14) fire extinguisher; (15) pilot's thigh rests; (16) Hydromatic propeller; (17) coolant header tank; (18) pilot's seat; (19) inter-com.; (20) engine controls; (21) elevator trim tab hand wheel; (22) carburetor air intake; (23) oil and coolant radiators; (24) pilot's harness; (25) throttle and propeller controls; (26) oil trap; (27) radio transmitter; (28) radio compass; (29) oil tank; (30) dump tank filler cap; (31) dump tank; (32) inboard fuel tanks; (33) outboard fuel tanks; (34) dump fuel tank release gear; (35) stringers; (36) navigation lamp; (37) identification lamp; (38) aileron control; (39) flap jack and crank; (40) flaps; (41) rear camera; (42) stowage for camera heating cables; (43) plywood inner skin; (44) balsa; (45) plywood outer skin; (46) bulkhead No. 6; (47) rudder mass balance; (48) bulkhead No. 7; (49) trim tab; (50) rudder linkage; (51) trim tab; (52) pitot head; (53) bulkhead No. 5; (54) camera mounting boxes; (55) spike pickets; (56) DF loop; (57) lamp; (58) radio; (59) compressed air container; (60) de-icing fluid tank; (61) bulkhead No. 4; (62) ground starter plug; (63) pneumatic hydraulic panel; (64) oxygen bottles; (65) hydraulic tank; (66)

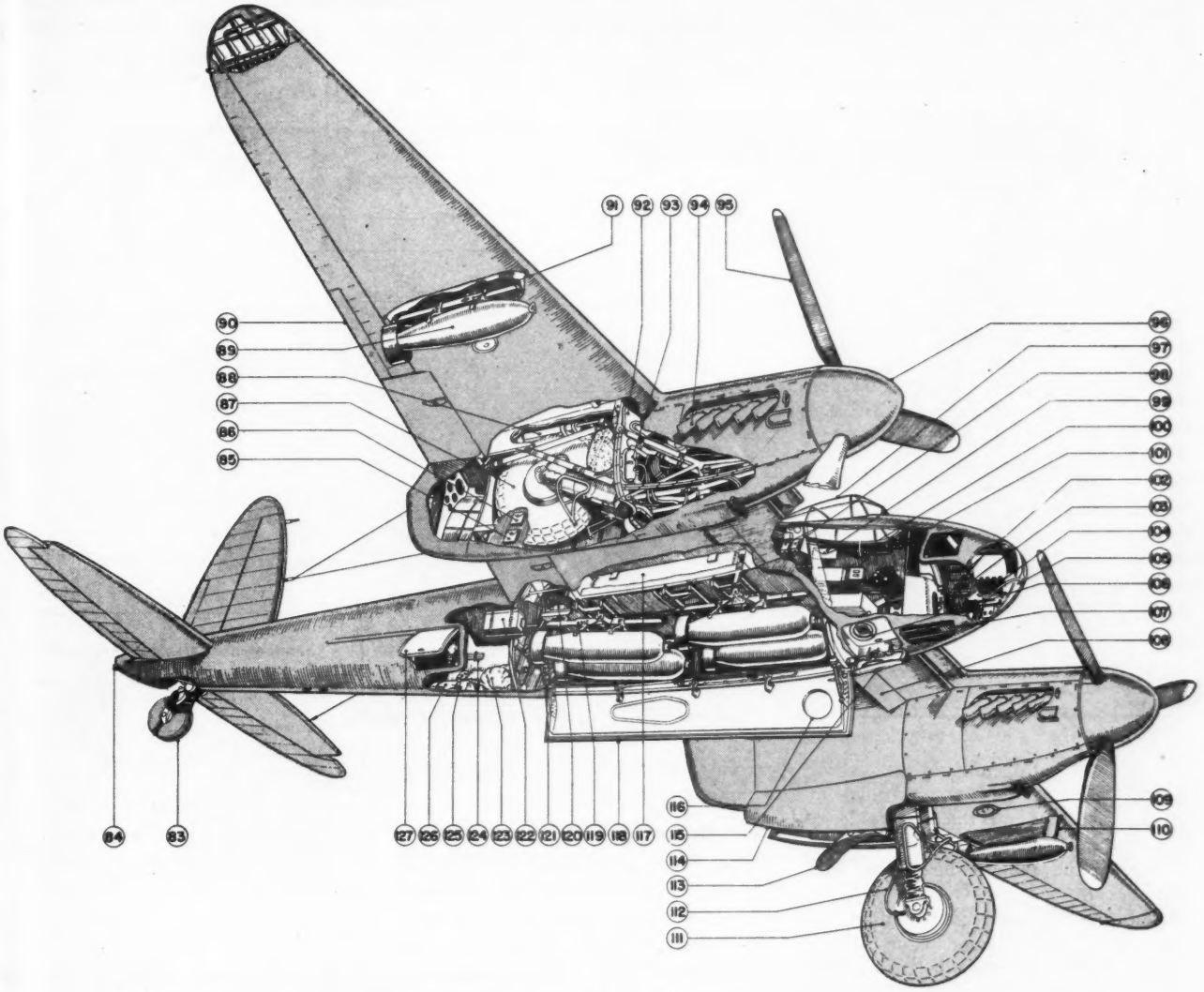
Use of wood and employment of the wood working industries, it is felt, contributed largely to the speed with which the *Mosquito* was put into production. It is built in three types: Bomber, fighter, and photo-reconnaissance.

The *Mosquito* is now being constructed in North America by deHavilland Aircraft of Canada, Ltd. Launching of the Canadian version introduced many new engineering problems since all of the manufacturing equipment had to be purchased on this side of the Atlantic. This required a tremendous amount of re-engineering before attaining production. On this score, much credit is due W. D. Hunter, Canadian chief engineer; H. Povey, chief production engineer; F. H. Burrell, chief service liaison engineer, who came from the parent company in England; and W. J. Jakimiuk, chief Canadian design development engineer.

The power plant of the Canadian version consists of two Rolls-Royce *Merlin* 31, 33, or 225 Packard-built engines, each rated at 1,260 bhp.

DeHavilland's long experience in building all-wood airplanes has been fully utilized. Chief feature of the design is the balsa-plywood sandwich principle used in constructing the fuselage and other structural wood parts. Prior to the war this fabrication was successfully applied to deHavilland *Albatross* four-engine transports.

Wood- construction has many advantages, according to *Mosquito* designers. It materially reduced the time required to design and produce the prototype, compared with a metal



long range oil tank; (67) aerial mast; (68) dinghy stowage; (69) antenna loading unit; (70) pilot's armor; (71) observer's seat; (72) trailing aerial winch; (73) observer's armor; (74) oil and coolant radiators; (75) double top skin and stringers; (76) single under skin and stringers; (77) aileron tab control; (78) observer's demand oxygen regulator; (79) instrument panel; (80) camera temperature gage box; (81) camera leads stowage; (82) inspection lamp stowage; (83) tail wheel stowage; (84) navigation light; (85) stowage picketing eyes; (86) stowage, landing gear locking cap; (87) landing gear retracted; (88) landing gear jack; (89) 500-lb. bomb; (90) aileron trim tab; (91) universal bomb carrier; (92) firewall; (93) fire extinguisher; (94) stub exhaust; (95) propeller; (96) spinner; (97) cockpit canopy; (98) radio remote control boxes; (99) pilot's pouch; (100) pilot's demand oxygen regulator; (101) dimmer switches; (102) signal cartridges; (103) fire extinguisher; (104) thermos bottles; (105) glycol spray; (106) tail drift sight; (107) ladder stowage; (108) radiator flap; (109) landing light; (110) wing bond fairing; (111) landing wheel; (112) brake hose; (113) mud guard; (114) landing gear doors; (115) entrance door; (116) camera window; (117) center fuel tank; (118) bomb bay doors; (119) bomb carriers; (120) bomb winch; (121) bomb bay door jack; (122) ration container; (123) engine covers, sleeping bags, etc.; (124) locking controls, stowage; (125) signal strips; (126) emergency tool kit, and (127) rear entry door.

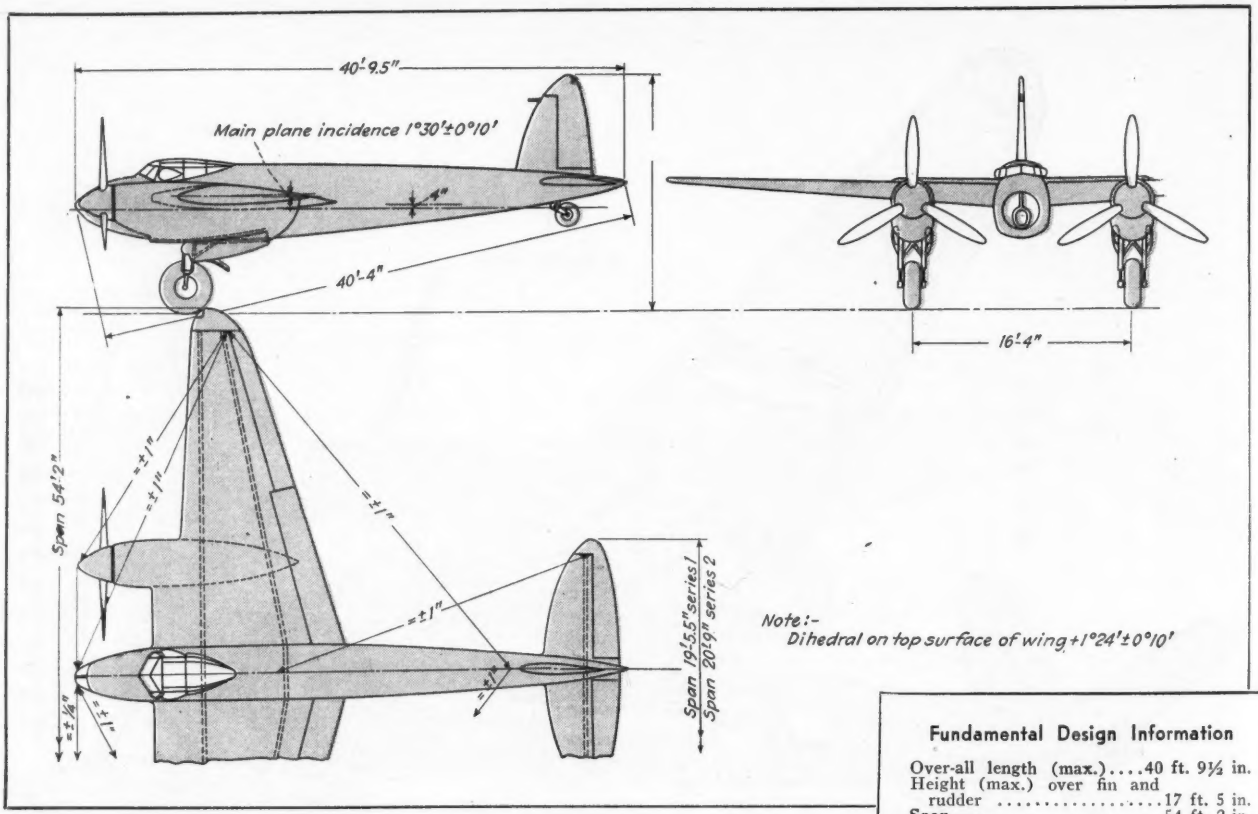
ship. Wood design is also one of the quickest methods yet devised to produce a monocoque type unit, and by using split fuselage construction, the craft is one of the easiest in which to install equipment. It utilizes the skilled labor of wood-working trades, which were greatly curtailed by the war.

Structurally, the plane also has many advantages. Due to comparatively low skin stresses and light weight of the wood, it is possible to produce a fuselage that offers more resistance to buckling than a metal one of the same weight per square foot. The system of molding fuselages makes them remarkably free from "waviness." When finished they are fabric covered.

The one-piece full cantilever wing is also of all-wood construction. It is formed on two full-length box-type wood spars. The top skin is made from two 0.25 in. plywood skins separated by Douglas fir stringers. Also of wood construction are the tailplane, fin, and flaps.

Engines and main landing wheels are mounted on the wings and completely streamlined by sheet metal nacelles and folding landing gear doors. Inside the nacelles there is a metal bulkhead or firewall attached to the front wing spar. This is secured to the same brackets to which the tubular framework, which supports the engine in front and the main landing gear in the rear, is attached.

Engine coolant and oil radiators are mounted in the leading edge of the wing between the fuselage and each engine nacelle. Cooling air enters



Fundamental Design Information

Over-all length (max.)	40 ft. 9½ in.
Height (max.) over fin and rudder	17 ft. 5 in.
Span	54 ft. 2 in
Wing area (net)	440 sq. ft.
Taper ratio (root chord/tip chord)	3.2 to 1
Length root chord (25 in. from fuselage centerline)	12 ft. 3 in.
Length tip chord (300 in. from fuselage centerline)	3 ft. 10 in.
Fuselage depth (max.)	5 ft. 5½ in.
Fuselage width (max.)	4 ft. 5 in.
Design gross weight, Canadian handbook	21,313 lb.

through a fixed opening in the leading edge, and air flow is controlled by adjustable flaps on the underside of the wing. Provision is made to deflect a part of the radiator-heated air into the cockpit.

The landing gear is as unique as the rest of this all-wood plane. Here, rubber blocks are provided to cushion landing shocks. This rubber-block design is applied to both main landing and tail wheels.

How unusual the *Mosquito* design really is can better be judged by a careful analysis of the various units which comprise the ship:

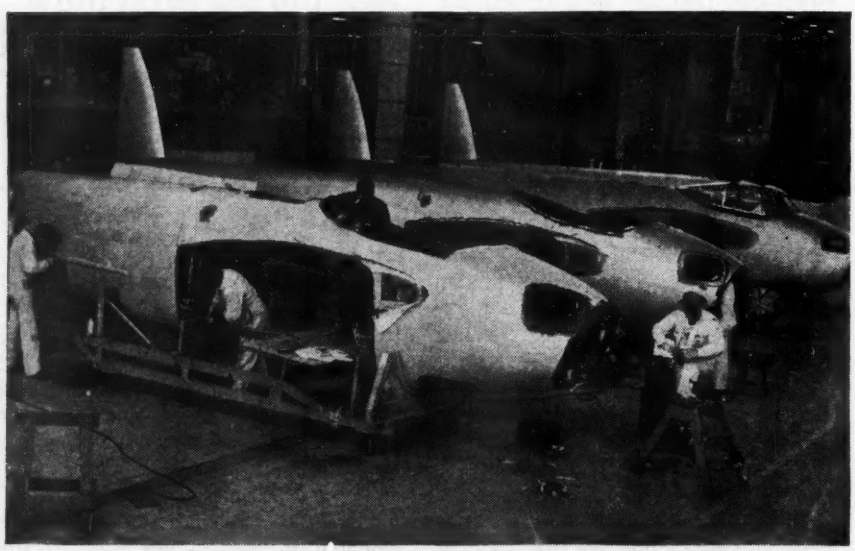
Design Features—Fuselage

The complete fuselage is made up as a balsa-plywood sandwich, the 0.437-in. balsa being compressed between two 0.062-in. 3-ply spruce or birch skins. Since balsa wood varies greatly in weight—from 5 to 30 lb. per cu.ft.—it must be carefully selected. Weight of that used in the *Mosquito* averages about 9 lb. per cubic foot. With a large volume used, this is an important item in the final weight of the ship.

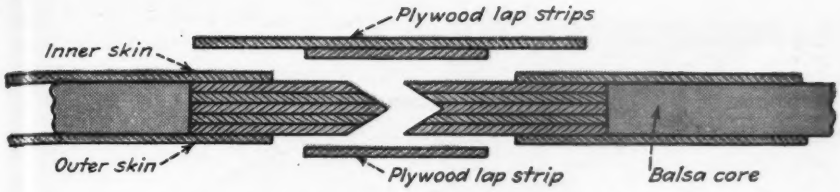
Kind of plywood and direction of grain is changed to suit stress conditions. In the section from mid-cockpit forward to bombardier's window, 3-ply spruce is used. Here the fuselage has a sharp compound curvature, requiring narrow strips, taper cut, with two plies lengthwise and one transverse.

From the forward spruce plywood section back to about 6 in. aft of bulkhead No. 5, 3-ply birch is used. This forms about 60 percent of the fuselage. It is laid on the structure with the outside grain running longitudinally. The bomb bay doors are included in this section, also the bomb bay side panels beneath the wing, the latter having diagonal grain instead of longitudinal. The bomb bay door panel has inside and outside skins that are preformed before assembly. The under wing section is glued in place with the rest of the fuselage and cut out after the finished-half fuselage is completed. All other panels, in as large sheets as possible, are carefully scarfed together and glued in place.

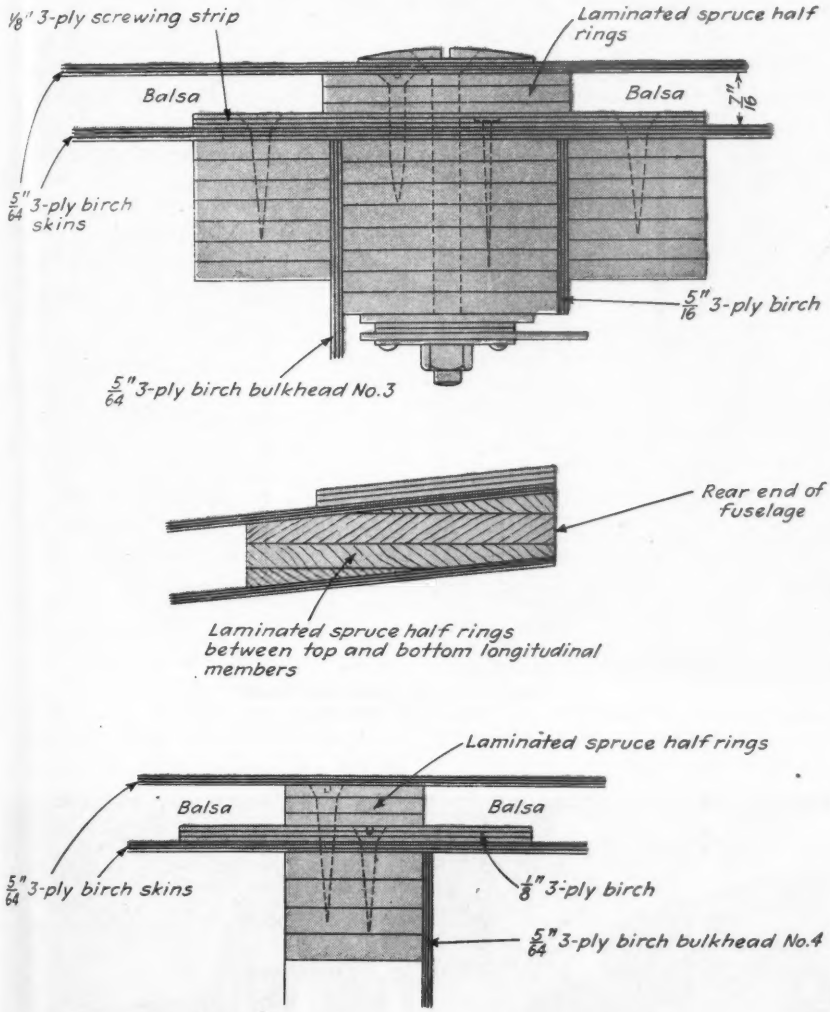
The rear fuselage section, which includes bulkheads 6 and 7, is also made



Fuselage as received from a subcontractor, with preparation for fitting windows, doors, and canopy before mounting on wing.



Details of skin joint where fuselage halves are mated. Plywood lap strips are glued and screwed into the shell members.



Methods of reinforcing monocoque walls at bulkheads.

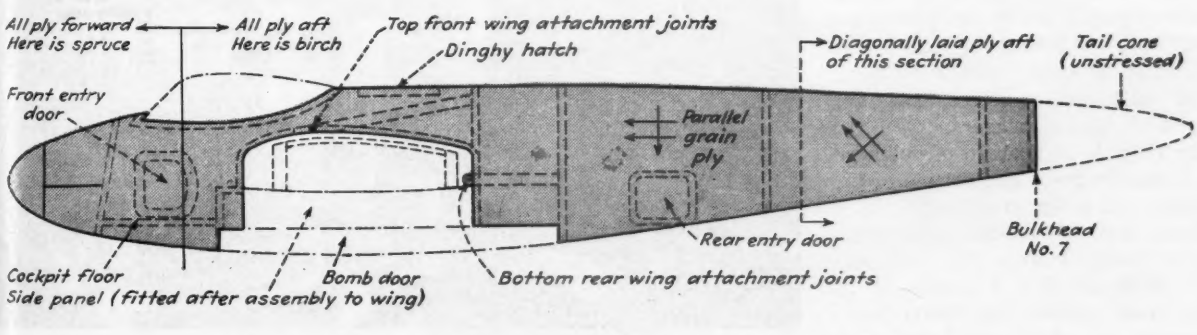
with birch plywood, but the grain is laid on diagonally, better to resist torque of the empennage. All vertical joints between panels are arranged to be not less than six inches away from a bulkhead. All longitudinal joints are made to lap over the spruce stiffening stringers.

In fabrication the fuselage is built up in two halves on separate right and left hand jigs. The wing openings on each side, cockpit aperture on top, dinghy compartment opening, and ends of the fuselage are left open during construction. Top and bottom edges of each half are reinforced with spruce laminated members. Where the two multi-ply strips bear against each other, "V" grooves in each half accurately center the edges but are not glued. Inner and outer plywood skin is stepped off each side of the joint so that a lap strip of equal thickness to the outside skin can be applied. This is glued and tacked in place, both inside and outside the assembled fuselage. It is further strengthened inside by a 0.12-in. 3-ply birch strip twice as wide as the first one applied.

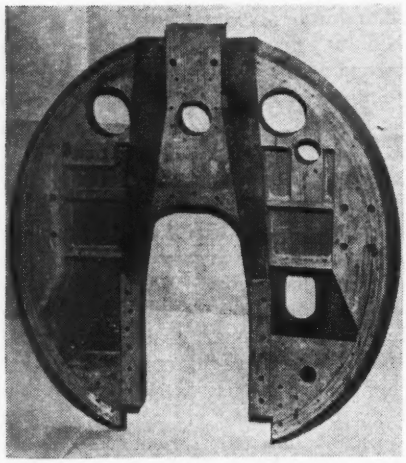
Union of the two halves does not depend entirely on bonding of these top and bottom edges. Of the seven bulkheads, six are made in halves and have a butt joint on the vertical centerline of the fuselage. The rear No. 7 bulkhead is made in one piece and inserted at the time the two fuselage halves are mated.

Wherever there is a bearing between parts that are bolted or fastened together, fabric reinforced Bakelite is used to prevent compression of the softer wood at these points. The Bakelite is faced with 0.50-in. birch veneer to assure a secure bond when glued to plywood members.

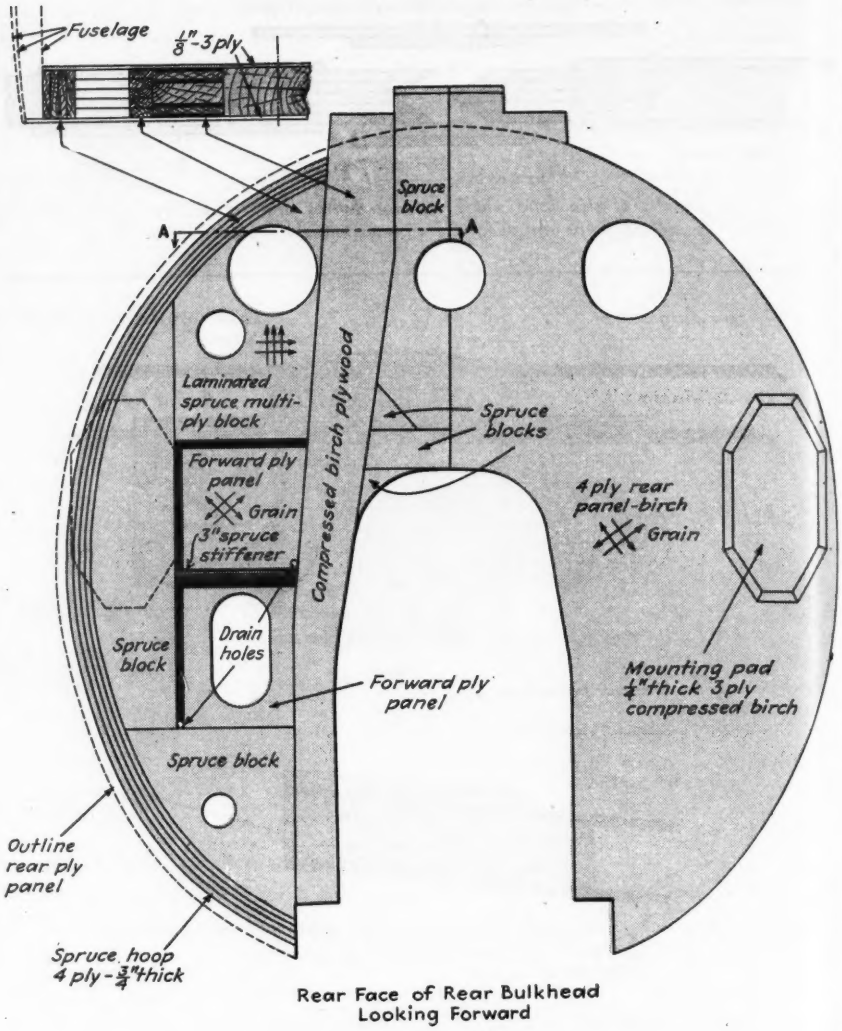
Ends of the fuselage are reinforced by laminated and formed half circles glued between the inner and outer skins. They are of the same thickness as the balsa core. All openings are reinforced around the edge by solid


All ply forward Here is spruce
All ply aft Here is birch
Top front wing attachment joints
Dinghy hatch
Diagonally laid ply aft of this section
Tail cone (unstressed)
Front entry door
Parallel grain ply
Rear entry door
Bulkhead No. 7
Cockpit floor
Side panel (fitted after assembly to wing)
Bomb door
Bottom rear wing attachment joints

Fuselage construction, showing general arrangement and location of bulkheads.



Detail of rear bulkhead No. 7, looking forward. Left half is shown with plywood facing removed to reveal material and structure.



Rear Face of Rear Bulkhead
Looking Forward

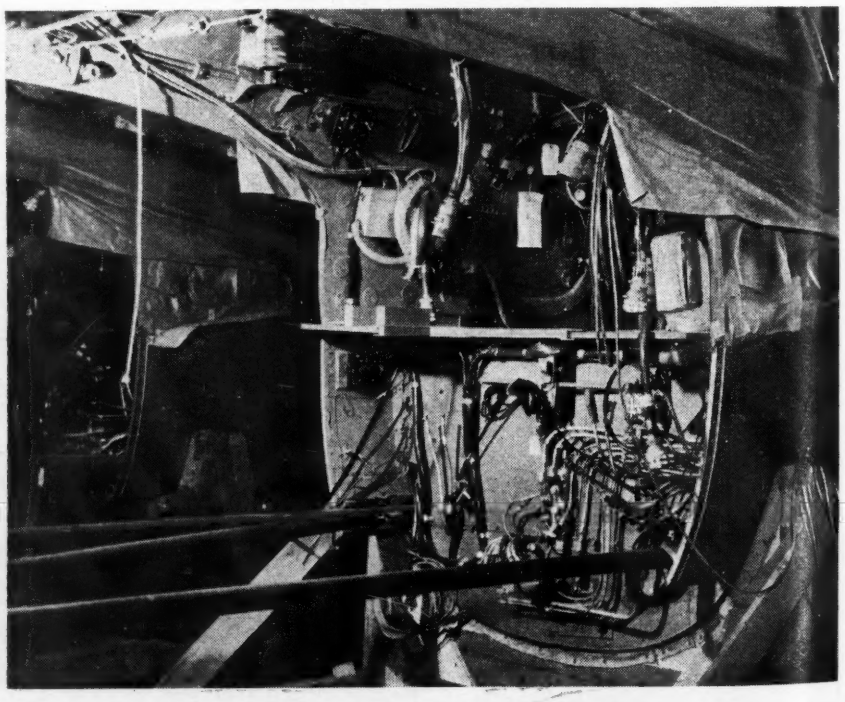
spruce, walnut, or laminated and formed members. In addition, two stringers are built into each half and extend from No. 3 bulkhead to No. 7. These are buried between the skins in the balsa core. Only external stiffening member is a long half-round piece on the left side of the fueslage rear above the rear entry door. The upper stringers tie into No. 3 bulkhead and run forward about 1 ft. to include the rear end of the wing pickup member.

Bulkheads

Method of assembling bulkheads is the same for all except No. 7. Intermediate bulkheads are all located in their proper stations in the fuselage build-up mold, and the inner skin is stretched over them. Glue and screws are both used for attaching skin to bulkhead. There is a 0.12-in. 3-ply screw strip approximately double the width of the bulkhead thickness glued to the inner skin, through which are driven screws to secure bulkhead.

Next, formed laminated spruce semicircular pieces of same width as the bulkhead are glued and screwed on top of the first strips and are also screwed directly into the bulkhead. Combined height of the two pieces, attached to the bulkhead but outside the inner skin, is equal to the balsa core. These bulkhead reinforcements are stopped off at the stringers.

The front floor forward of bulkhead No. 2 reaches from side to side of the fuselage, and when joined with No. 2 bulkhead and instrument panel structure it greatly stiffens the front section. Bulkhead No. 3 carries at its outer lower corners the heavy reinforcements to which the lower wing pickup brackets are bolted. These are attached not only to the bulkhead but



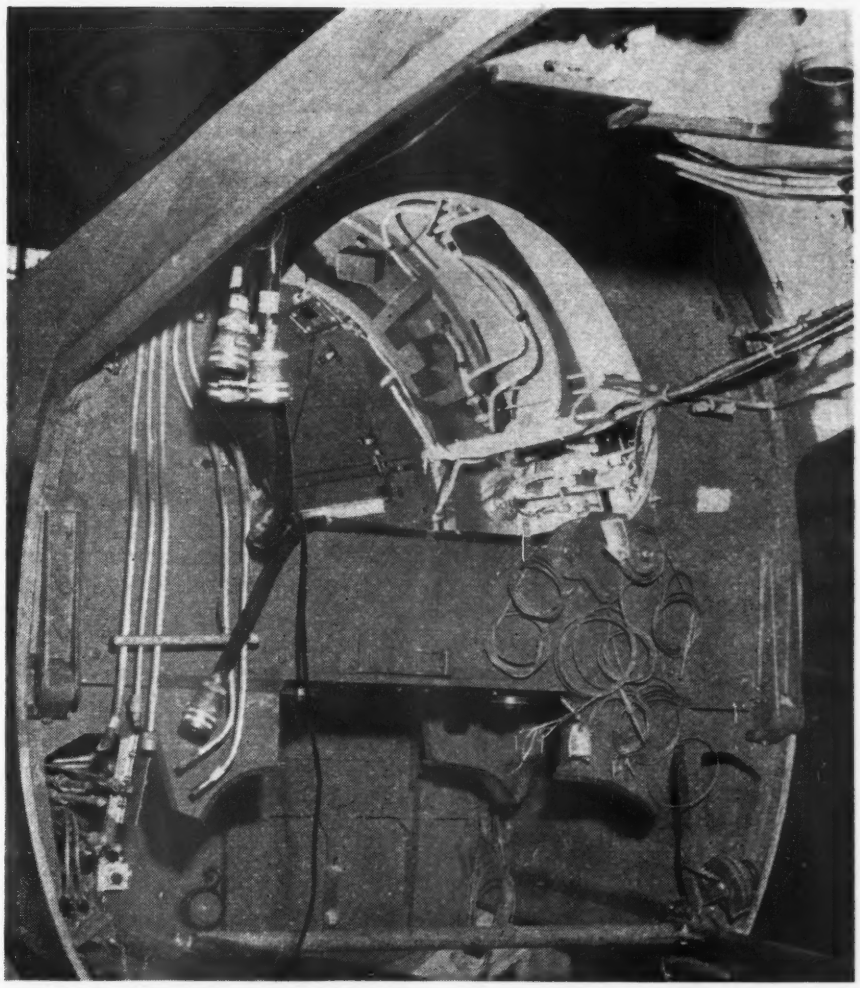
Looking forward into nose section, showing cockpit, also No. 2 bulkhead fittings which are installed prior to mating with wing. Note tubular bracing which supports fuselage.

also to side of the fuselage and forward ends of the lowest stringers built into the aft section. These stringers are of larger section for about 40 in. aft of the bulkhead in order to distribute stresses over more of the fuselage at this point.

Probably the heaviest load of any member in the fuselage is carried by the rear bulkhead, for it supports the tailplane and tail wheel, also shares fin and rudder reactions with bulkhead No. 6. It is a composite structure built up of many types and forms of wood. Spruce blocks, either solid or laminated, are provided for certain parts. The outside edge is made from a 4-ply spruce half ring. The two members which run vertically on either side of the opening are compressed birch plywood. At top they support the rear bracket of the fin, while at the bottom they carry the tailwheel bracket and tailplane rear spar braces. The whole unit is tied together by 0.12-in. 3-ply birch facings glued to each side.

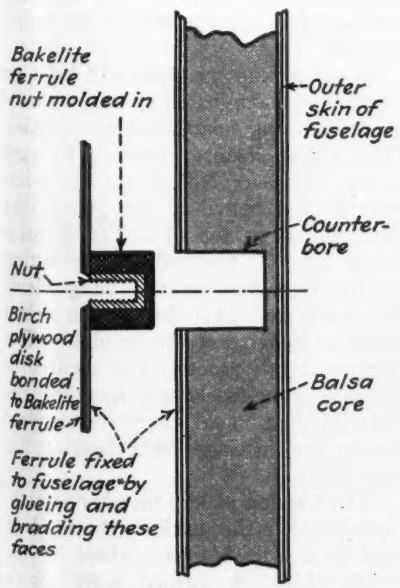
The side panels which finally close the opening below the wing are held in place by a 2.0x0.12-in. aluminum plate which covers the front end gap. This end plate is securely bolted. At the rear end, two 1.62x0.06-in. aluminum strips are placed on each side of the panel and held with through-bolts. These strips align the rear edge with the aft skin of the fuselage. They close a gap or expansion joint about 0.37-in. wide at the rear end. The panels are only a closure, since the wing is the structural member which ties together the fore and aft lower edges of the fuselage.

Just behind the cockpit opening and above the wing is a small bulkhead. Behind this in the top of the fuselage are two more openings—the rectangular front one for the dinghy, the circular aft one for the radio mast support. The cover over the dinghy, in event of immersion, may be instantly released by an electric trigger operated from a switch in the lower part of the fuselage.

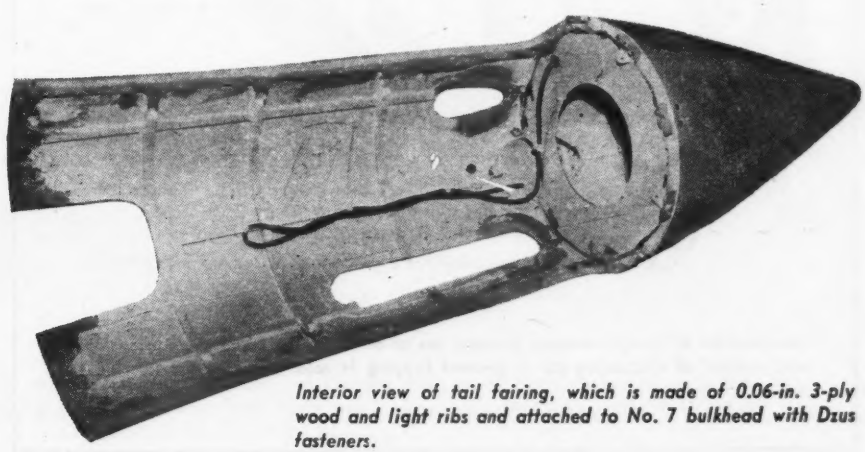


View aft of wing opening, showing bulkheads 3 and 4, fittings for picking up rear spar, and wing centering bracket. Note how all cables, tubes, and fittings end here for easy installation of wing; also temporary tubular braces are attached to bomb door hinge brackets.

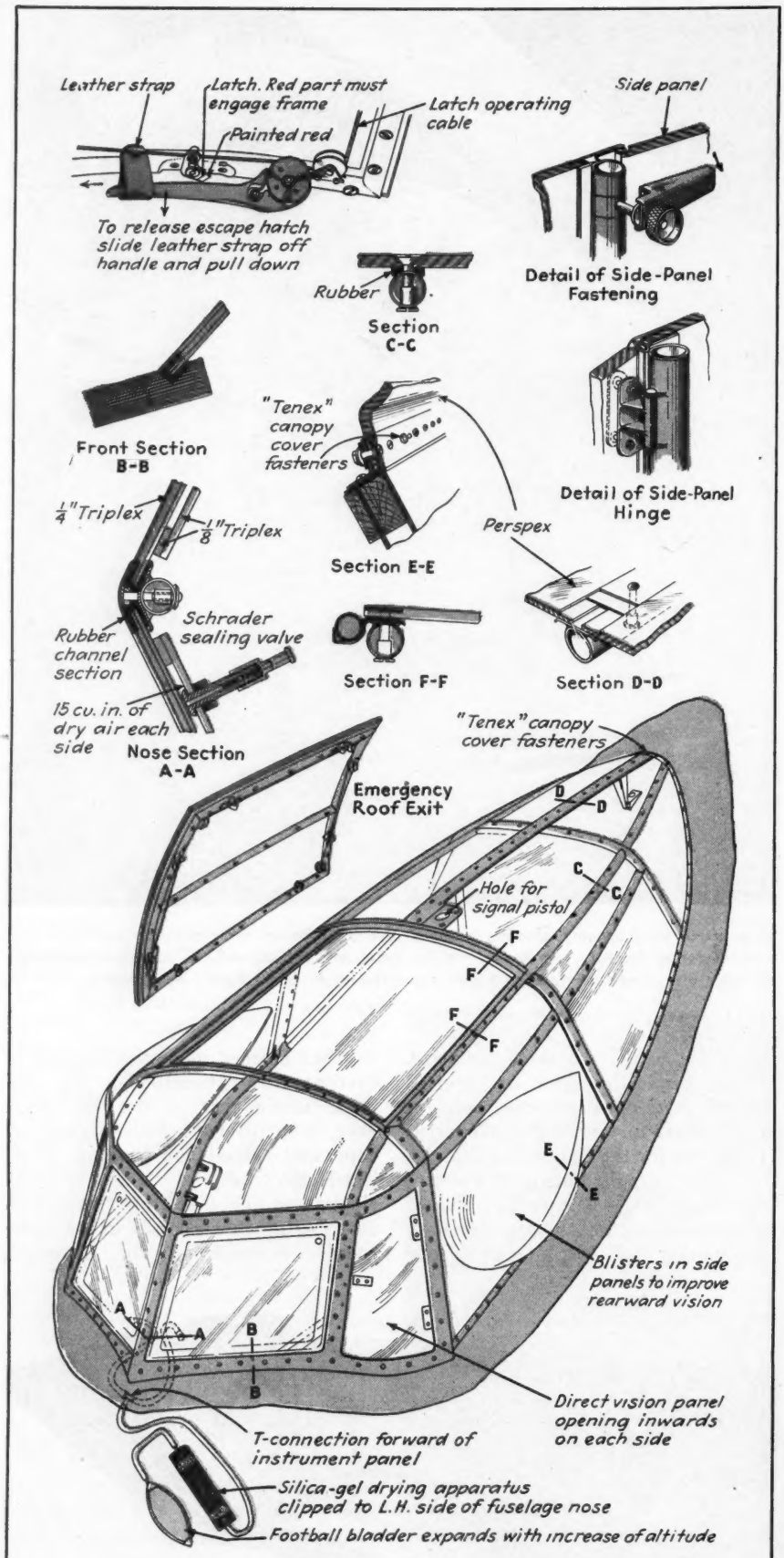
When finished the entire fuselage is covered with Mandapolam, an airplane fabric that is stretched with dope, then painted. Several coats of dope well rubbed down assure a finished smoothness of skin, free from ripples and of course from rivets, thus contributing tremendously to the high-speed performance of the *Mosquito*.


Bakelite ferrule nut molded in
Outer skin of fuselage
Counter-bore
Nut
Birch plywood disk bonded to Bakelite ferrule
Balsa core
Ferrule fixed to fuselage by glueing and bradding these faces

Unique method used in fastening accessory mounting units in wall of fuselage.



Interior view of tail fairing, which is made of 0.06-in. 3-ply wood and light ribs and attached to No. 7 bulkhead with Dzus fasteners.


Leather strap
Latch. Red part must engage frame
Painted red
Latch operating cable
To release escape hatch slide leather strap off handle and pull down
Side panel
Detail of Side-Panel Fastening
Rubber
Section C-C
Front Section B-B
"Tenex" canopy cover fasteners
Detail of Side-Panel Hinge
Perspex
1/4" Triplex
1/8" Triplex
Section E-E
Schrader sealing valve
Rubber channel section
Section F-F
Section D-D
15 cu. in. of dry air each side
Nose Section A-A
"Tenex" canopy cover fasteners
Emergency Roof Exit
Hole for signal pistol
Blisters in side panels to improve rearward vision
Direct vision panel opening inwards on each side
T-connection forward of instrument panel
Silica-gel drying apparatus clipped to L.H. side of fuselage nose
Football bladder expands with increase of altitude

Construction of cockpit canopy showing use of air space in triple plate windshield, also method of evacuating air to prevent fogging in cold or high altitudes.

Also the wood structure is so stiff that rippling of the skin in flight does not occur and interfere with the ship's speed. Importance of this finish is illustrated by the results when using a night-flying "velvet" black paint. It is claimed that difference in paint smoothness frequently caused a speed loss of as much as 25 mph.

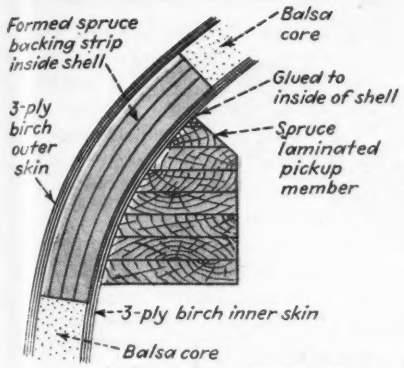
Method of fastening equipment and attachments to the inside of this perfectly smooth fuselage is ingenious. Templates are provided for locating bracket holes into which Bakelite-molded ferrules are glued. Each ferrule has a brass nut molded inside of it and a 2-in. diam. 2-ply birch disk glued to the outside end. When glued and bradded in place, these nuts make a secure foundation for any attachments. Electric motor driven countersinks, with a secure stop, control the depth of counterbores in the fuselage, so the outer skin will not be mutilated.

The canopy over the cockpit is built up on a welded steel tubular frame with an angular flange along the lower edge to fasten it to the fuselage. There is an escape opening in the top with a quick release latch. Removable windows at each side of the "V" windshield provide direct vision if necessary.

The triple-plate anti-fogging "V" windshield windows incorporate a unique system for exhausting the air space between them. Each is connected by a tube with a Schrader air valve. Air can be sucked out but its return is prevented by the valve. A small bladder attached to the outlet tube provides the exhaust system. It expands as the ship climbs, thus the air is sucked out of the hollow windshield. A tube of silica-gel is inserted in the suction line so as to remove moisture contained in the air within the windshields.

Wing pickup members are built up from 0.4-in. laminated spruce with the grain running lengthwise in all plies. The pickup member extends forward from bulkhead No. 3 to the point where it is bolted to the fitting that is mounted on top of the front main wing spar. The adjustable fitting which is bolted to the wing clevis bracket is secured to the wooden pickup member by top and bottom plates. The pickup at this point is also secured to the side of the fuselage by five through-bolts with a metal compression plate inside the fuselage as a bearing for the nuts.

The wooden pickup member is carefully fitted to the inside of the fuselage and then screwed and glued to the inside skin. A formed 4-ply spruce backing strip forms the core of the fuselage behind the pick-up member.



Section through fuselage shell where spruce wing pick-up member is screwed and glued to it. This important part carries front wing attachment joint.

This is glued and screwed in place before the outer 3-ply skin is applied.

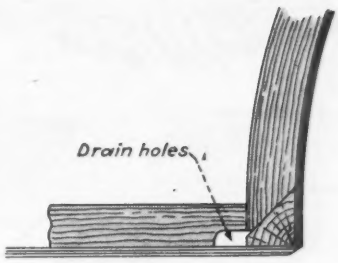
A serrated block, tapped out for the adjustable pick-up fitting, is secured between top and bottom metal plates by through-bolts. Transverse grooves relieve the holding bolts of any shearing stresses in a fore and aft direction. The adjustment is ingenious. A sleeve is threaded inside and out with a hex nut on the end. The threads are of opposite hand so the sleeve acts like a turnbuckle. Check nuts are provided on both sleeve and bolt so the whole nut can be locked when adjustment is complete. The wing holding nut is slipped in place through a hole provided in the fuselage skin and secured by a castellated nut.

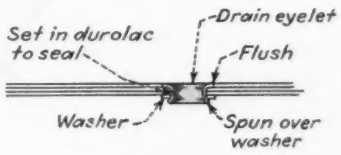
Drainage of a wooden ship is of vital importance. There are scupper holes provided between ribs and spars, or similar members, throughout fuselage and wings. Holes with flush eyelets are provided at all drain points.

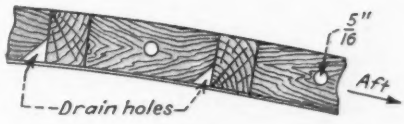
Bonding is another one of the vital features on a wood ship. Every metal bracket or metal part is connected to every other one by flexible metallic tape. This is usually glued to wood members before they are painted. Bonding is soldered to all permanent metal fittings to assure a perfect electrical connection.

Main Wing

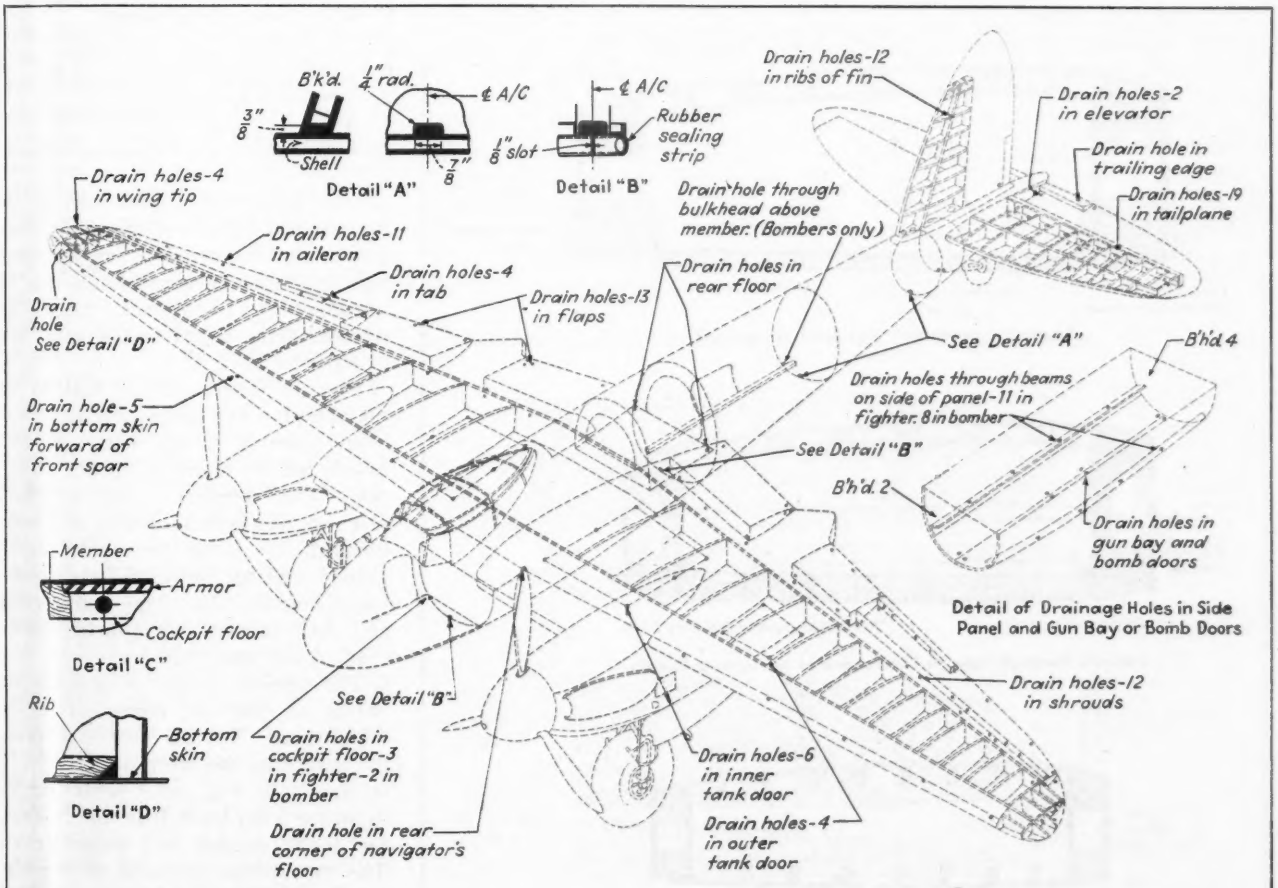
This is the main load carrying structure of the *Mosquito*. It carries the engines, landing gear, radiators, gas and oil tanks, and the bomb racks.



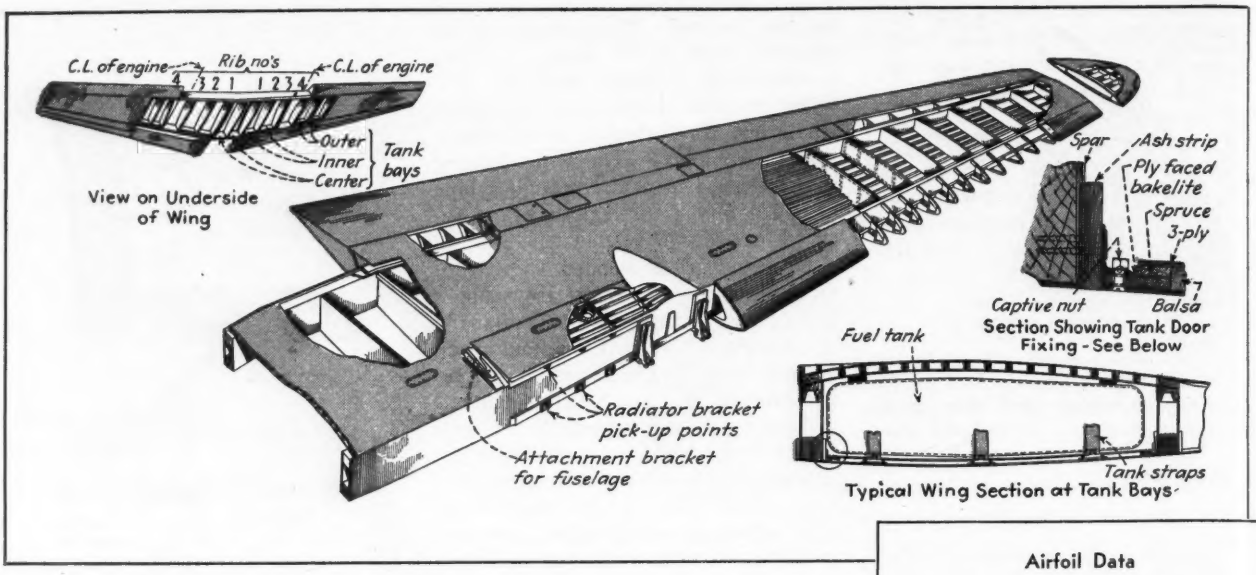




Types of drainage openings used.


B'h'd.
1/4" rad.
℄ A/C
3/8"
Shell
7/8"
Detail "A"
℄ A/C
1/8" slot
Rubber sealing strip
Detail "B"
Drain holes-12 in ribs of fin
Drain holes-2 in elevator
Drain hole in trailing edge
Drain holes-19 in tailplane
Drain holes-4 in wing tip
Drain holes-11 in aileron
Drain holes-4 in tab
Drain holes-13 in flaps
Drain hole through bulkhead above member. (Bombers only)
Drain holes in rear floor
See Detail "A"
B'h'd. 4
Drain hole See Detail "D"
Drain hole-5 in bottom skin forward of front spar
Drain holes through beams on side of panel-11 in fighter. 8 in bomber
See Detail "B"
B'h'd. 2
Drain holes in gun bay and bomb doors
Member
Armor
Cockpit floor
Detail "C"
Detail of Drainage Holes in Side Panel and Gun Bay or Bomb Doors
Drain holes-12 in shrouds
See Detail "B"
Rib
Bottom skin
Detail "D"
Drain holes in cockpit floor-3 in fighter-2 in bomber
Drain hole in rear corner of navigator's floor
Drain holes-6 in inner tank door
Drain holes-4 in outer tank door

Location of drain holes. (An all wood airplane, although protected by paint, must also be perfectly drained. Even parts not exposed may absorb moisture condensed within, so that every point of possible collection must be included.)



It is built up as a single unit to which the wing tips, leading edges, and control surfaces are added. The all-wood fuselage is lowered on top of the center section, to which it is secured by four pick-up bolts and a centering bracket.

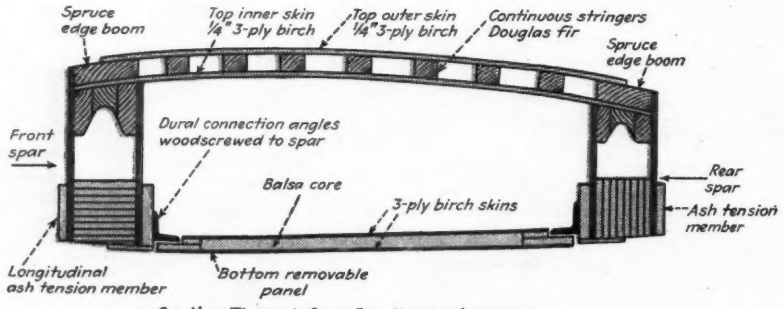
Briefly, the wing from tip to tip is built upon two huge box spars with 0.25-in. plywood webs and laminated spruce flanges. Top of the wing is of double thickness reinforced by spanwise Douglas fir stringers sandwiched between two layers of 0.25-in. 5-ply birch. The leading edge, of formed ply-wood, is attached to the front spar. Bottom of the wing, composite in construction, provides openings through which the tanks may be introduced. These are closed by stressed skins bolted to the spars and to adjacent ribs.

From the outermost fuel tank to the tip, the plywood under-skin is permanently secured to the wing and also reinforced by spanwise spruce stringers. The complete wing is glued, screwed, and bolted together and when finished is fabric covered, doped, sanded, and painted until it is exceedingly smooth. The flaps and ailerons and their fairings are attached to the rear of the spar box.

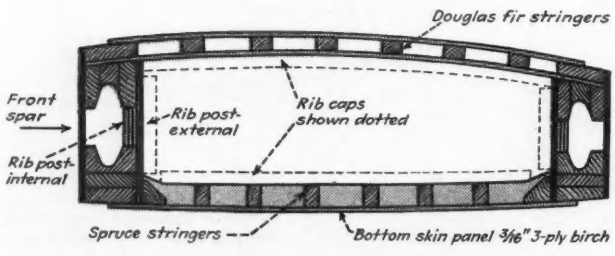
The section of the wing spar box varies at different points along the wing span. Typical section between the center of the wing and rib No. 6 is shown in Fig. 6A. This part of the wing takes loads from the fuselage, fuel tanks, engines, and undercarriage. The top section is made of two plywood panels with stringers running lengthwise between the panels. The bottom section is composed of detachable panels made as plywood-balsa sandwiches.

Airfoil Data

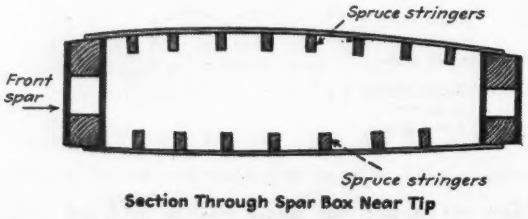
Root airfoil, Piercy Modified	Section RAF 34
Tip airfoil, Piercy Modified	Section RAF 34
Root chord (outboard of airplane centerline)	25 in.
Tip chord (outboard of airplane centerline)	300 in.
Wing area (net)	440 sq. ft.
Angle of incidence	Plus 1½ deg.
Dihedral (measured on top face of front spar)	1 deg. 24 min. ±10 min.
Sweepback at rib No. 4	2½ deg.
Aspect ratio	6.67
Aileron area (two ailerons)	34.4 sq. ft.
Aileron location (distance from fuselage side to centroid of aileron area)	196.2 in.
Aileron static balance, approx.	6 percent mean
Trim tab chord (chord aft of aileron hinge line is 0.8 in.)	4.3 to 4.5
Trim tab span	41.37 in.
Trim tab area (each tab)	1.1 sq. ft. (total 2.2 sq. ft.)



Section Through Spar Box Near Wing Root



Section Through Spar Box Outboard of Removable Panels



Section Through Spar Box Near Tip

Three sectional views through spar box.

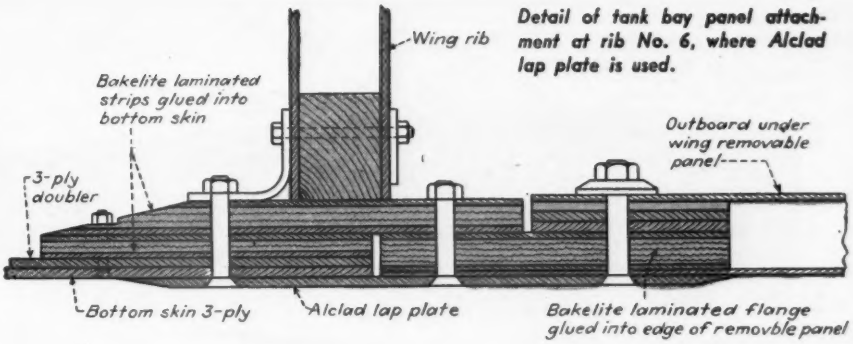
The box spar section of the wing between ribs 6 to 12 is shown in Fig. 6. Top skin is of the same construction as between the center and rib No. 6; bottom skin is fixed and made of a single panel of plywood with longitudinal stringers. From the 13th rib to the wing tip there are only single plywood skins on top and bottom of the wing.

Each spar consists of two flanges of booms, top and bottom, joined by two 0.25-in. 5-ply birch webs on each side. These vary in height from about 16 in. at the root of the wing to about 5 in. at the wing tip end. In plan view, the spars also taper from root to tip. The front spar varies in width from 4.37 to 1.26 in. At the bottom edges of each spar in the load carrying section long 4-ply-ash tension strips are added for reinforcement. Top flanges of both front and rear main spars are made from three laminations of 1.5-in. thick spruce, scarfed and spliced together vertically in the thickest section. Flanges are approximately 4.37-in. wide and 3.62-in. deep. They are lightened between the points of rib attachment by spindled slots approximately 2.12-in. deep, with 3.62-in. openings, and with 25-deg. tapered sides.

Lower flange of the front spar is made of 0.4-in. horizontal laminations. In the rear spar, the lower flange has vertical laminations in order to facilitate fabrication. The front spar is practically straight all the way across the wing. The rear spar, although parallel to the front one throughout the center section of the wing for about 5 ft., sweeps forward at an angle of about 10 deg. on either side of the mid-section and also upward at an angle of about 3 deg. The vertical laminations in the rear spar are more easily formed to these angles.

On the face of the front spar, hardwood or Bakelite packings are used to distribute pressure of the metal brackets that support the engine and landing gear. On the inside of the rear spar, similar packings are provided where the landing gear brackets are attached. Space between the vertical 3-ply sides of the spar is filled in at each main rib, also wherever a bracket is applied. Additional vertical spacers are found at ribs, 1, 3, 4, 6, 9, 14, and 16, and between 11 and 12. Where possible the upper flange is spindled out between them.

The lower front flange is built up in three sections, the major one at the center with horizontal 0.4-in. laminations that extend approximately to rib No. 6. Then three heavier laminations are used until the spar becomes a solid piece from rib 12 to the tip. Long scarfs of 1/15 ratio are used at the transition points. Provided at rib attachment points on the inside of the wing spars are 1-in. square vertical spruce blocks. These are screwed through the plywood to a similar block on the inside, at points where the screws do not enter either the top or bottom boom. The ribs are glued and screwed to these spruce blocks. The plywood web grain runs diagonally when the spar is in its horizontal position.

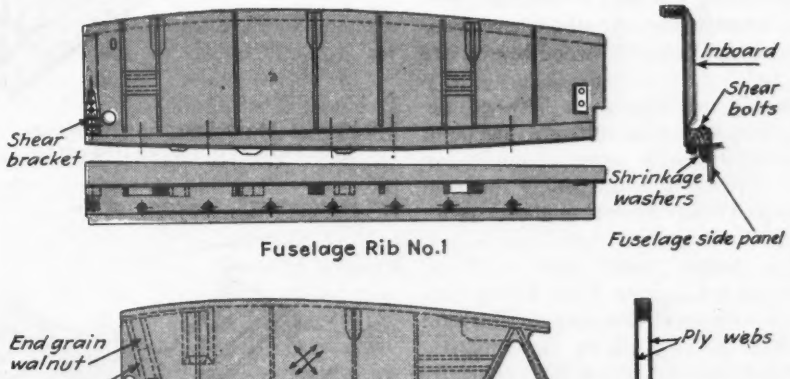

Wing rib
Bakelite laminated strips glued into bottom skin
3-ply doubler
Outboard under wing removable panel
Bottom skin 3-ply
Alclad lap plate
Bakelite laminated flange glued into edge of removble panel

Detail of tank bay panel attachment at rib No. 6, where Alclad lap plate is used.

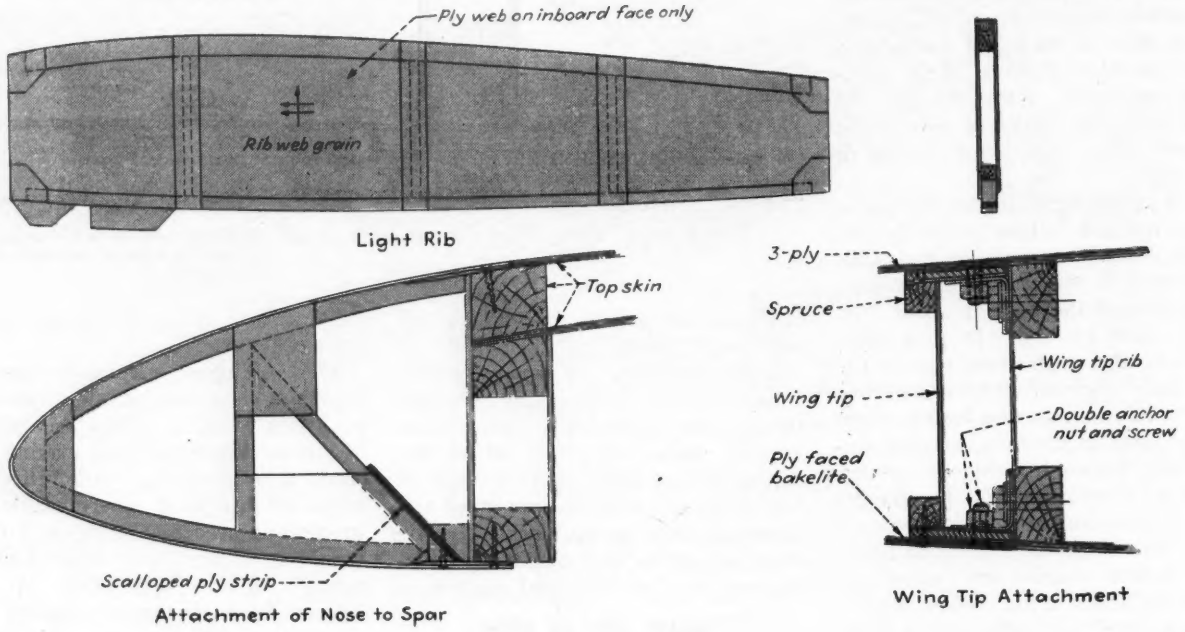
Double Skin on Wing

Top skin of the wing is made up of two ¼-in. 3-ply birch skins separated by 1.3-in. maximum thickness Douglas fir stringers that extend spanwise from tip to tip. At each edge there is a wide spruce boom (between the two skins) that is superimposed over each spar, thus adding to their strength. In between the wide-edge booms fifteen narrow Douglas fir stringers are equally spaced. At the center section of the wing they are parallel to one another, but outboard of the fuselage, although equally spaced, all incline together at different angles. For reference purposes they are numbered from 1 to 15, No. 1 being the first aft of the front edge spar.

These stringers have to be bent at something less than 10 deg. between wing ribs 1 and 3. They are spliced in this section to facilitate making the bend, also increasing their effective width at this point where maximum strength is needed. Stringers 1 to 4 and 11 to 15 are 1.0-in. wide, while 5 through 10 are 1.6-in. wide. At the root of the wing they are spaced approximately 4.37 in., center to center. At rib 3 the spacing, due to wing taper, has been reduced to about 3.82 in. Outward of rib 6 all 15 stringers are the same width, 1.0 in. Incidentally, rib 6 forms the outboard wall of the most outboard fuel tank. Between ribs 8 and 9, stringers 7 and 13 terminate and stringers 4 and 10 end on rib 9, so that only 11 pass beyond this point. At rib 11 all stringers have been reduced to 1.0-in. thickness and 0.75-in. width. At this point the 1.0x0.5-in. stringers start, and spacing is about 2.30 in. Spruce is specified for the 0.75- and 0.5-in. stringers instead of Douglas fir. Between ribs 13



Wing details. Note heavy ribs.



Light ribs and attachment of leading edge and wing tip.

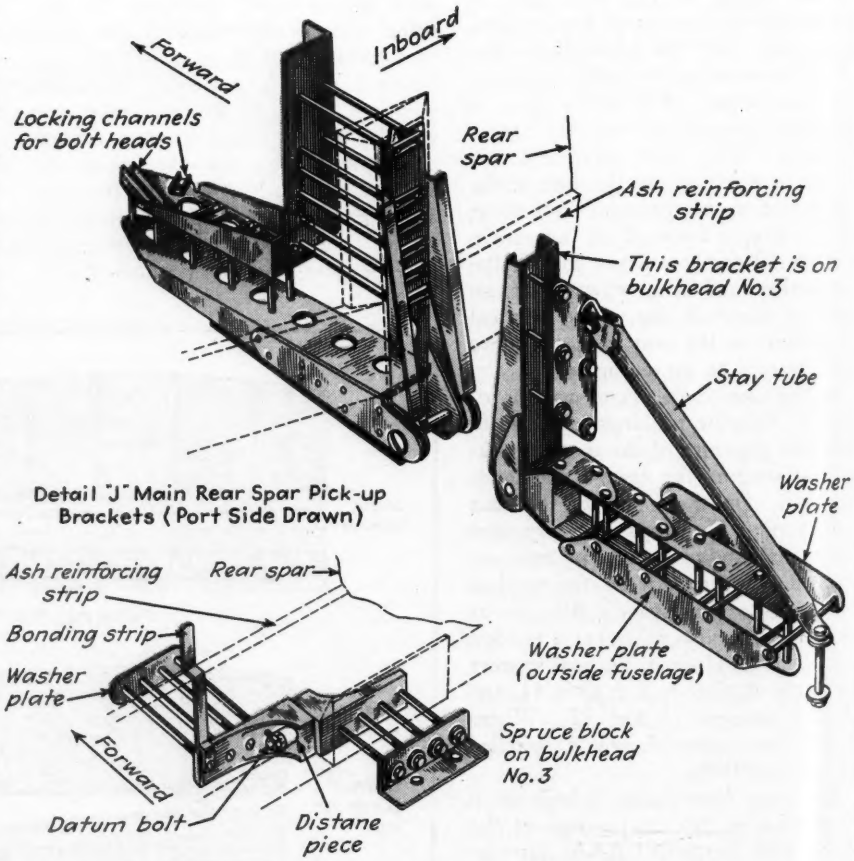
and 14, stringers 1, 6, and 12 terminate, while between ribs 14 and 15 stringers 3, 9, and 15 stop. This leaves 2, 5, 8, 11 and 14 to end on wing tip rib No. 16.

The stringers are separated by wood blocks over ribs 1, 3, 4, and 6 and the top skin is bolted through to the rib at these points. Elsewhere the top and bottom skins are screwed to the stringers after gluing. Screws are put in at intervals of 3 in., the upper and lower skin screws being offset 1.50 in. to distribute the load evenly and prevent interference. At ribs where there are through bolts, the wood screws are left out.

Double top skin ends between the 12th and 13th ribs. From this point outward there is only a single top skin. Near rib 8 the single top skin is spliced into the top dual skin with a full 3-in. scarf.

The single under skin, 0.187-in. thick, is made from 3-ply birch reinforced with spruce stringers. This skin extends from rib 6 to the wing tip and is glued and screwed permanently in place.

The bomb bay doors enclose the center section of the wing from port rib 1 to starboard rib 1. From rib 1 outward, both sides of the wing follow the same pattern so that description of one serves for both. The space between ribs 3 and 4 forms the wheel well. Between ribs 1 and 2, 2 and 3,



Metal fittings which form lower rear connection between fuselage bulkhead No. 3 and lower rear edge of rear wing spar.

4 and 5, and 5 and 6, four fuel tanks are suspended from the ribs in each side of the main wing. The landing gear is enclosed by a metal fairing, hence this portion of the wing bottom surface does not have to be covered. The four fuel-tank access openings, however, must be closed.

One cover panel serves to enclose the two fuel tank openings inboard of the wheel well; a similar one protects the two outboard tanks. These give a perfectly smooth bottom to the wing where they are attached, since flush screw heads are provided and the edges are faired into the wing.

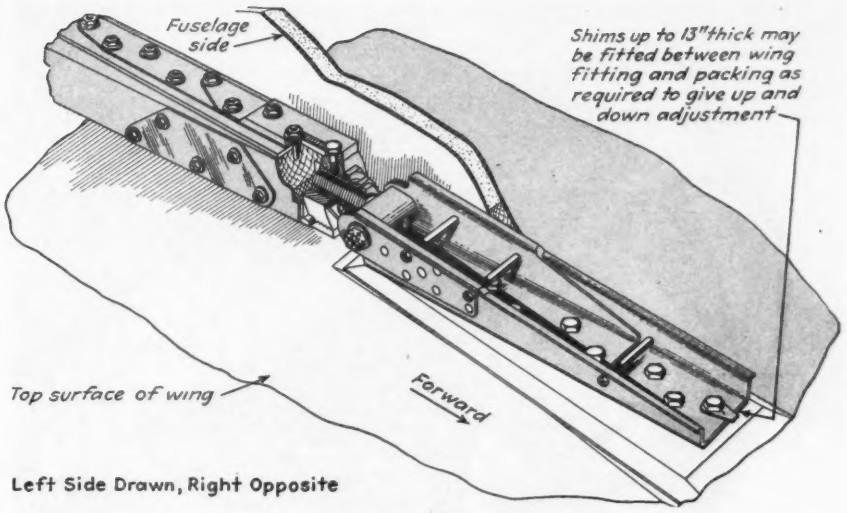
Like the fuselage, the tank-bay covers are plywood and balsa sandwiches. The main constructional feature is use of laminated fabric reinforced Bakelite sheets having a 0.050-in. birch veneer facing for bolting strips. This permits gluing Bakelite to edges of the tank-bay panels and to bottom skin of the wing where the bolted joint is made. The Bakelite has a bearing stress value of 35,000 psi. and provides a non-crushable bearing for attachment screws. For further protection and strength, Alclad lap plates are provided, with three rows of countersunk bolt holes for the joint along the edge of rib 6. The nuts are held captive with metal covers riveted to structural rolled aluminum angles. These angles are fastened to the inside faces of front and rear spars by wood screws. The angles are made up in 1-ft. lengths and each carry four fastened nuts. Dividing these angles into sections allows for any expansion or contraction of the wood. The angles are mounted in the 3.0x0.5-in. ash tension members at the lower edge of each wing spar.

Attachment nuts along bottom edges of the ribs are riveted to wood ply-faced Bakelite flanges glued to the ribs. The intermediate rib between the fuel tanks also has a series of fastened nuts, so that the center of each panel is secured by bolts, with bottom of the rib accurately positioned. These Aerotight nuts are fastened either with wood screws, rivets, or bolts.

Wing Ribs

There are three types of wing ribs: No. 1 or fuselage rib, the double sided or box type ribs such as are used on each side of the wheel well, and the open faced or light ribs.

No. 1 ribs come just inside the fuselage contour and carry shear bolts which support the fuselage side panels below the wing. The web of these ribs is 3-ply birch 0.25-in. thick. They are reinforced with spruce flanges top and bottom, also by retangular vertical stiffeners. The bottom flange carries a Bakelite reinforcement connection strip, to which the inboard edge of the inner fuel tank cover panel is bolted.


Fuselage side
Shims up to 13" thick may be fitted between wing fitting and packing as required to give up and down adjustment
Top surface of wing
Forward
Left Side Drawn, Right Opposite

Front attachment joint between wing and fuselage, showing metal bracket fastened to front rib of pickup member and bracket bolted to wing above front spar.

The box type ribs are made with two 0.187-in. 3-ply birch sides and have walnut, birch, ash, or spruce stiffeners, depending on their location and purpose. Engine rib No. 3 is typical. The stiffeners are all grade-A spruce, and except for the top one they are all solid. The top flange is made from 0.27-in. spruce laminations and is approximately 0.8-in. deep over its full length. The lower flange averages 1.3-in. deep. The solid spruce vertical stiffeners are 0.4-in. wide. Outside width of the rib measures 2.0 in. Semi-circular cut-outs are provided in the side panels through which the Aerotight nuts can be inserted. Bolts that go through the upper double-skin catch the nuts inserted in the top flange of this rib. Nuts holding the lower panel are inserted through similar holes in the web above the bottom rib.

To distribute load, the cutouts are alternated, first on the left web then on the right. The bolt holes are spaced approximately 3 in. apart. Spacing of the screws that clamp the rib stiffeners and side panels together is also kept at about 3 in. Ply-faced Bakelite is glued to the bottom to carry the tank panel fastening nuts. These are omitted on double panels where they bear against underskin stringers instead of against a tank door.

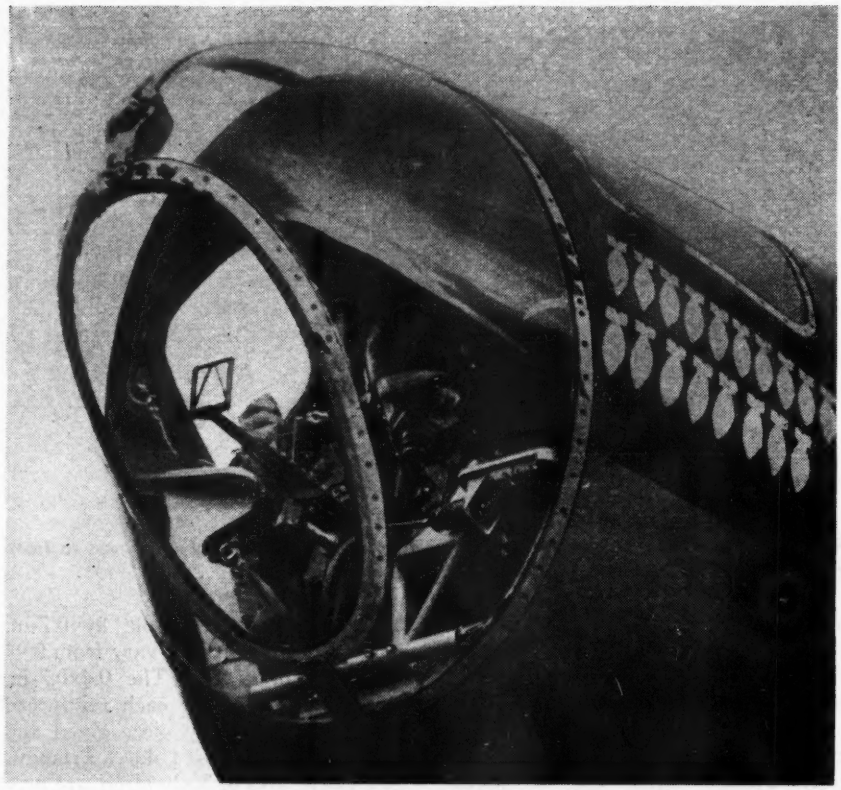
Single web ribs are made in two weights: Those for ribs 7, 8, 12, 13, and 15 have a 3-ply 0.0625-in. thickweb; the others have 0.078-in. webs. All are made from 3-ply birch with the web located on the inboard face. The top and bottom flanges are solid spruce. The lower one varies in depth from 0.6 to 0.7 in. by 0.7-in. width. The top flanges vary from 0.97 to a 0.65-in. depth. The 0.4x0.7-in. vertical stiffeners are each reinforced by a 1.4x⅞-in. 3-ply piece glued and bradded to the exposed side. Triangular gussets, also of 3-ply birch, are provided at corners of the rib.

There are 16 ribs on each wing, not counting the double-sided box-type rib which is located at the center of the ship. The latter is used to help support the bomb racks. Ribs on each side of fuel tanks and wheel wells are box type. There are also two other box type ribs, Nos. 8 and 14. These are located at critical points, the first where aileron control reactions take place, the latter at the outboard aileron support.

Wing tips are bolted in place just like the tank bay doors, with flush screws that engage captured nuts on wing end rib No. 16. These nuts are held by an aluminum cuff bolted to the wing end rib. The wing tip has a spruce and laminated plywood rib that matches the wing and rib. Feature of this construction is provision of ply-faced Bakelite reinforcements all around the attaching point so that screws will not crush the tip or wing end at the joint when they are tightened up. The wing tip itself is constructed with a plywood outer skin glued and screwed to spruce formers and to a triple laminated spruce edge that gives the tip its proper contour.

Leading Edge

The leading edge of the wing is made up in four sections. Two of these, one right, the other left, extend outboard from engine nacelle to wing tip. They are slipped over the forward side of the front wing spars and screwed and glued in place. When as-



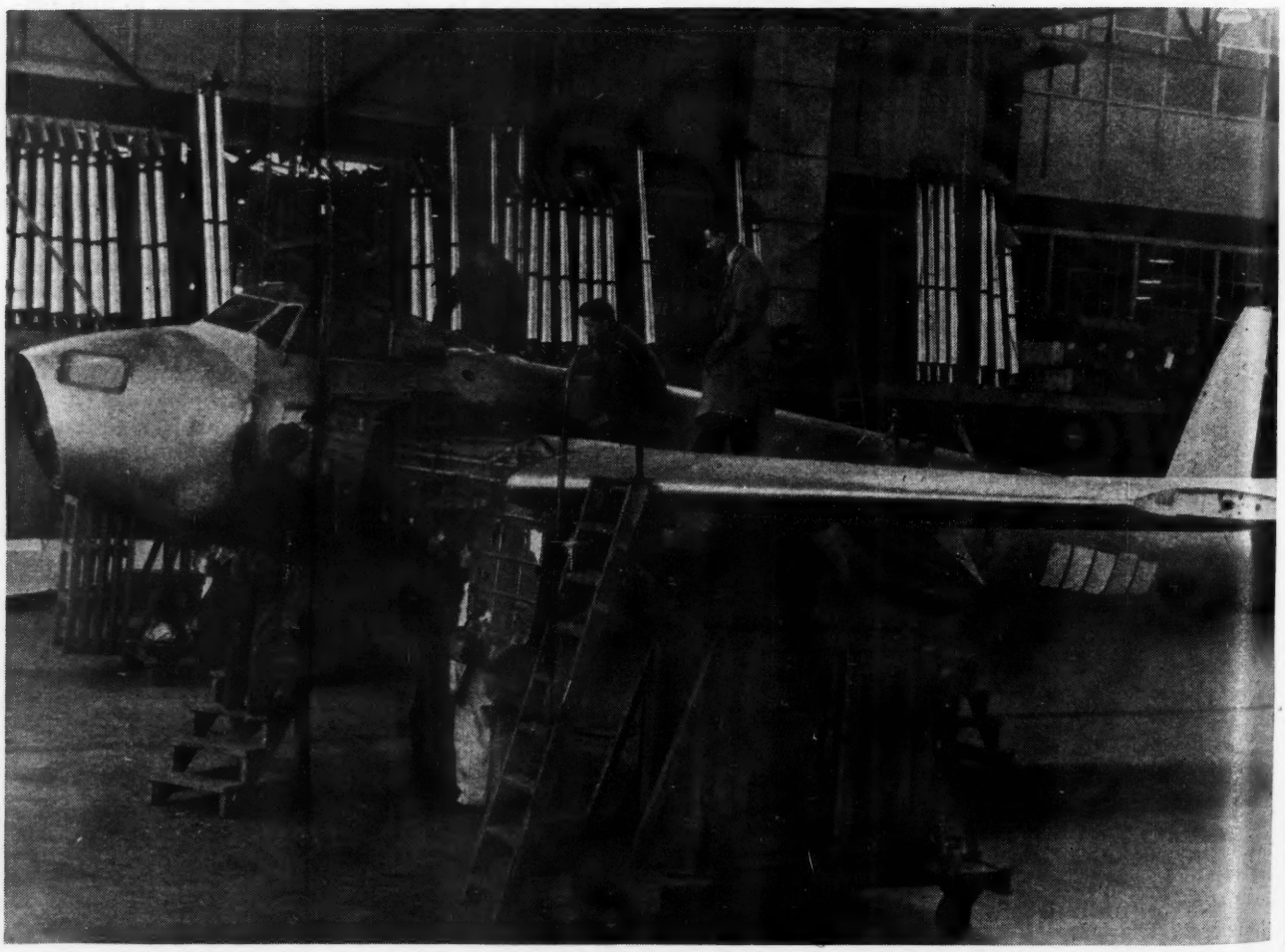
Plexiglas nose of "Mosquito" Bomber. Bombs painted in side show number of missions flown. .(Chas. E. Brown photo.)

sembled, they become a fixed portion of the wing unit. Each leading edge consists of a series of spruce nose ribs reinforced by 3-ply wood gussets and a longitudinal scalloped plywood strip set in at a 45-deg. angle. This structure is then covered with a pre-formed plywood skin that fairs into top and bottom skins of the wing.

Between engine and fuselage the second section of leading edge has been developed so as to form a housing for oil and liquid coolant radiators. It is constructed of 24ST Alclad sheet. The leading edge has a fixed opening that forms a duct through which air passes to the radiators. The rear bottom portion of each cooling unit has a two-position flap to control flow of air through the radiators.

Design Analysis of the deHavilland Mosquito *will be concluded in June* AVIATION.

Mounting of fuselage on wing. Truck jacks carry wing underneath, pickup pins are inserted on No. 3 bulkhead and rear wing spar, and fuselage is then lowered into place.



METHODS FOR DETERMINING AIRFOIL PRESSURE DISTRIBUTION*

By **MONROE A. MALLER,** *Hughes Aircraft Co.*

Specially collated for those who may be called upon to apply experimental data obtained from tests, here are the practical steps required in estimating airfoil pressure forces. Particularly treated are mechanics, test equipment, and wind tunnel models.

IN STRUCTURAL DESIGN AND ANALYSIS, the role of pressure distribution is an important one. Accordingly, the purpose of the following discussion is to provide a review of the fundamentals involved and their relation to the conception of pressure distributions.

It is first necessary to define a few physical quantities the significance of which will become evident as our discussion proceeds:

Since air is a gas, its *pressure* is of prime importance. Pressure is defined as *force per unit area,* which then fixes the definition of *force* as the *summation of pressures over a given area.* In a moving stream of air, application is made of two types of pressures which also justify definition. One of these is the *static pressure* of the air, which is the pressure due to the weight of the air alone. The symbol for static pressure is the letter p. The second type of pressure is called *dynamic pressure*—the pressure due to the velocity of the air alone. Obviously, when the air is still, the dynamic pressure is zero. The symbol for dynamic pressure is q, and its value is given by the expression —

$$q = \tfrac{1}{2} \rho V^2 \qquad (1)$$

where ρ is the mass density of the air in *slugs per cubic feet,* and V is the velocity in feet per second. The slug is a fundamental unit of mass and is expressed by weight divided by acceleration due to gravity, i. e., W/g. For air, the specific weight of which is 0.07651 lb. per cu. ft., the density in slugs is 0.07651/32.1740= 0.002378.

Sum of the static and dynamic pressure in a uniform horizontal flow is known as *total head pressure,* or more simply, *total head.* In equation form the sum is written —

$$p + q = H \qquad (2)$$

that is, the well known Bernoulli's Equation for incompressible flow which states that the sum of the static and dynamic pressures is a constant along any streamline. In wind tunnel testing it is customary to refer to the value of undisturbed total head in the test section as free stream total head, and it assumed conveniently that the value of total head is constant in a plane normal to the undisturbed flow.

One important property of pressure is that *a pressure is equally exerted in all directions.* This fundamental principle is very important in its applications.

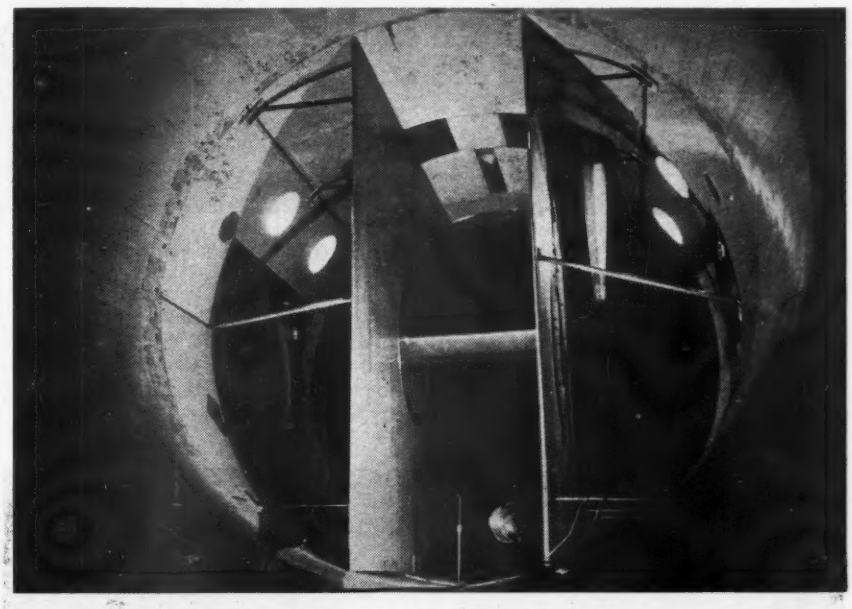


Fig. 1. Two-dimensional test sections rigged into Galcit wind tunnel.

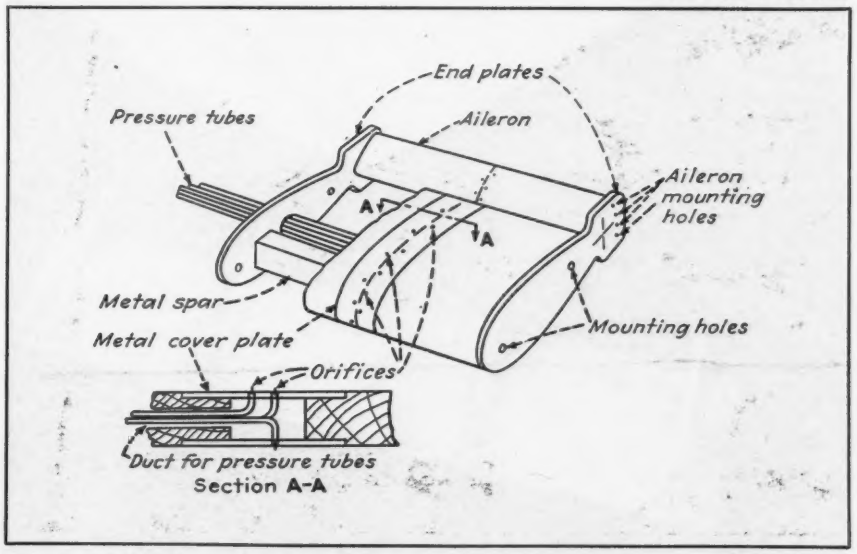


Fig. 2. Details of small-chord two-dimensional panel, with self-contained pressure orifices.

* Prepared by the author during his association with Consolidated Vultee Aircraft Corp.

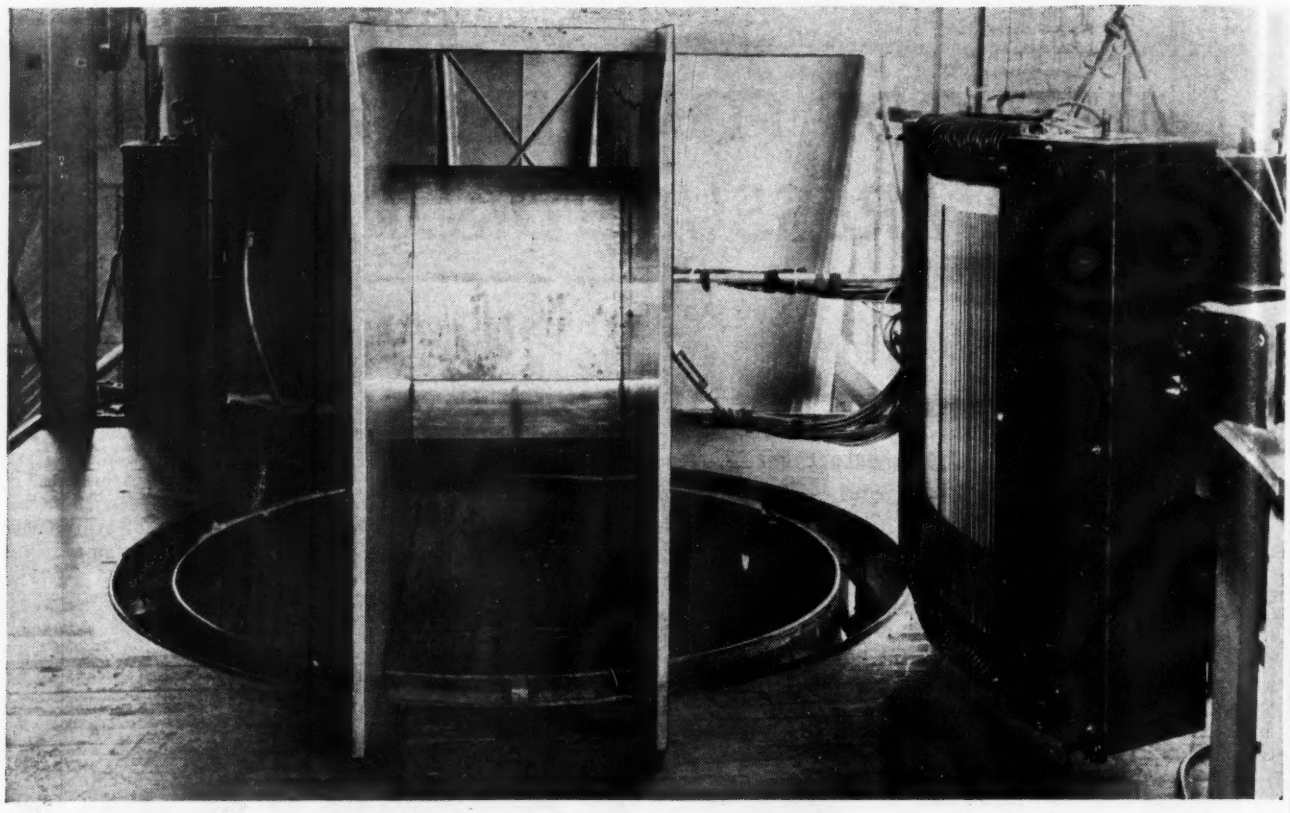


Fig. 3. Test arrangement in NACA 5-ft. vertical wind tunnel. (NACA photo.)

With these few basic facts established, consideration is given to the experimental techniques employed in conducting pressure distribution tests.

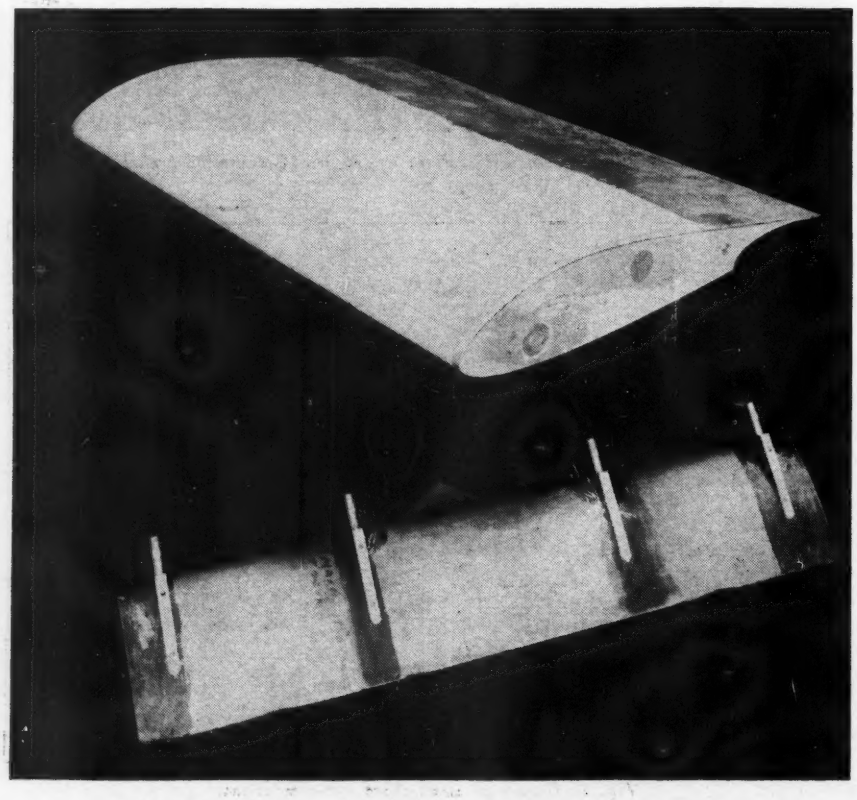


Fig. 4. Details of small-chord two-dimensional panel. (Convair).

Testing Technique

To obtain pressure distributions from wind-tunnel tests, it is necessary to construct special models. Because of the expense involved, these tests in the past were conducted only by those groups engaged in academic research or by a few of the larger aircraft manufacturers whose research allotments could defray the expenses.

The refinements in technique in this country, largely due to the work of the NACA, have been widely reported.[1] Measurements of airfoil pressure distributions have been nearly all two-dimensional, i.e., measurements of airfoils of infinite aspect ratio. In the usual three-dimensional wind-tunnel, these are accomplished by spanning a model of rectangular plan form across the test section. Where the size of the tunnel makes this impractical, a model of the airfoil is generally constructed with an aspect ratio of 6 and is mounted symmetrically in the tunnel; then the pressure distribution is taken about the midspan section of the model.

In either case, the angle of attack is corrected for the departure from true two-dimensional flow. This is done by computing the spanwise lift distribution, the details of which are not considered here. Suffice to say that from these computations, the vertical component of downwash velocity w, can be obtained, and the induced angle of attack in radians is—

$$\alpha_i = \frac{w}{V} \qquad (3)$$

[1] Probably the most complete paper describing testing technique is NACA T.R. No. 563, "Calculated and Measured Pressure Distributions Over the Mid-span Section of the NACA 4412 Airfoil Section", 1936.

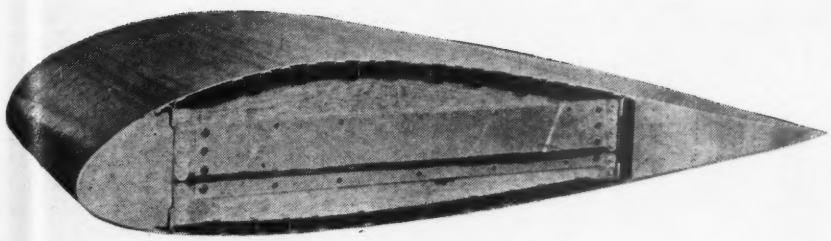


Fig. 5. Two-dimensional test panel of "typical manufacture" type. (Convair photo.)

which can then be reduced to the form—

$$\alpha_i = k\,C_l \qquad (4)$$

where: k is a constant

C_l is the section lift coefficient

The angle of attack for two-dimensional flow (infinite aspect ratio) is given as—

$$\alpha_o = \alpha - \alpha_i \qquad (5)$$

where α is the geometric angle of attack.

For pressure distribution tests, some of the big tunnels have been rigged with two-dimensional test sections in the regular working section. This is done by installing two large parallel plates extending from the floor to the ceiling of the test section and extending several chord lengths ahead and behind the model. These walls serve the two-fold purpose of, (a) reducing the span of the model, and, (b) rendering the flow between them nearly two-dimensional. The method is quite satisfactory, provided no adverse flow conditions are set up between the walls. Fig. 1 shows a typical installation employed by Consolidated Vultee during a series of tests in the Galcit tunnel.[2] It proved quite successful.

Two-Dimensional Models

The actual pressure distribution of an airfoil model in a wind tunnel is measured by means of a series of static pressure readings taken on both the upper and lower surfaces at various stations along the chord line. The technique used in measuring the static pressure is dependent on the type of model employed.

Our present discussion will be confined to two-dimensional airfoil models, of which there are two types. Substantially these are, (a) smooth surface models, whose primary purpose is in the determination of airfoil characteristics, and (b) large chord models, the construction of which is typical of actual production manufacture. The latter are primarily intended for drag tests but can be utilized in obtaining pressure distributions, as will be described later.

Construction of the smooth surface models is considered first. Principal components of this type of model are shown in Fig. 2. The metal spar is provided as an integral part of the structure, since large portions of the interior are removed to allow the pressure tubes to be led out. Pressure tubes are sweated into the cover plate, allowing a little of the tube to protrude beyond the surface. The protruding end is soldered closed and is then filed down until it is flush with the airfoil contour. Formation of the orifice is by drilling through the solder normal to the surface. Diameter of the orifice is usually .010 or .008 in. i. d. It is good practice to permit sufficient tubing to extend beyond the end plate to allow for breakage or crimping of the ends.

Component surfaces such as flaps, ailerons, and slats are usually constructed of metal. Orifices are located in these components by making spanwise grooves in the surfaces — grooves of a diameter slightly larger than that of the pressure tubing. The tubes (sealed at one end) are then laid in the grooves and sweated into place. Any chinks and discontinuities are filled in with solder, and the entire surface is then refinished so that the contour checks the master template. Orifices are then drilled into the sealed end of the tubing, normal to the surface.

Fig. 3 shows the application of a small-chord model with pressure tubing leading to the manometer. Fig. 4 shows some of the details of a typical small-chord smooth-type model.

Smooth-type models are also tested in chord lengths up to 5 ft. The larger models are used for tests at higher values of the Reynolds Number.

The "typical manufacture" model is intended to represent some portion of actual wing construction, and all external details, such as exposed rivet heads, lap joints, etc., are faithfully reproduced. No attempt is made to smooth out any of the manufacturing irregularities encountered in production. A model of this type is shown in Fig. 5. Tests on these models are primarily for determining the additional drag due to manufacturing irregularities, therefore pressure orifices are usually omitted from the construction. The pressure distribution is determined by exploring the surface of the airfoil with a so-called "mouse".

A "mouse" consists of a static pressure tube mounted on small brass feet attached to the surface of the model with scotch

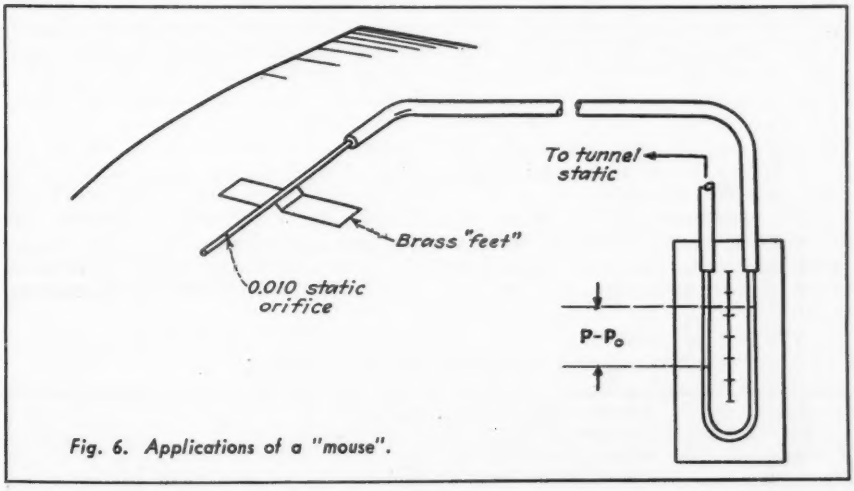


Fig. 6. Applications of a "mouse".

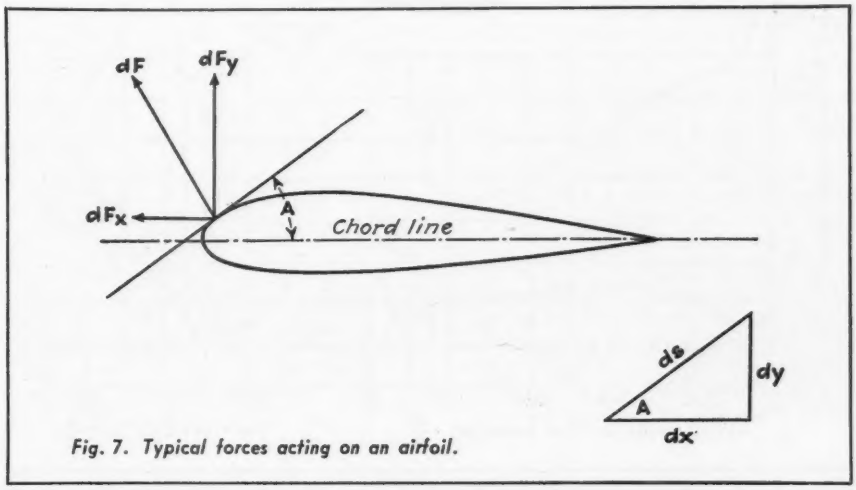


Fig. 7. Typical forces acting on an airfoil.

[2] Guggenheim Aeronautical Laboratory, California Institute of Technology.

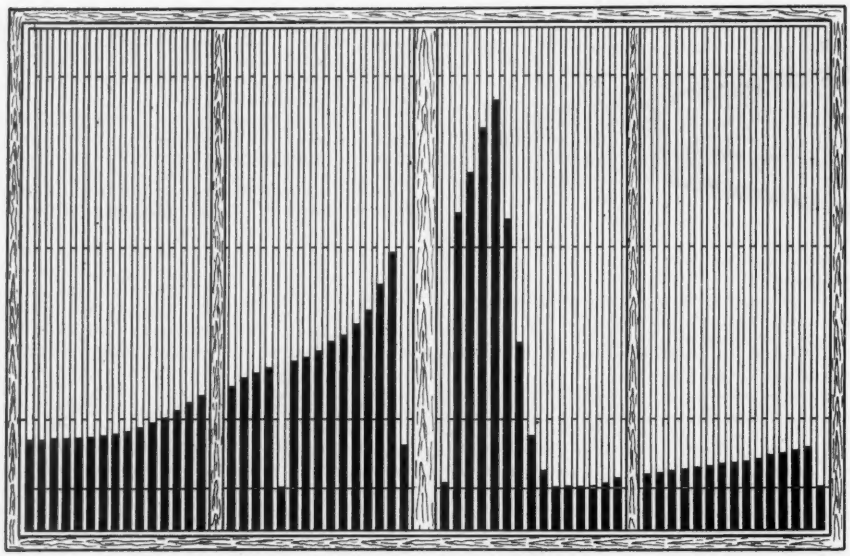


Fig. 8. Manometer board record.

tape. In application, the static orifice is located at various percentages of the chord, and the pressure is measured by connecting the mouse into the manometer, as shown in Fig. 6. Tunnel static is taken in the test section.

If the dynamic pressure q, is measured, using a manometer employing the same fluid medium as for the mouse, then the pressure coefficient P (to be derived later) is obtained by dividing $p_L - p_o$ (static pressure at the "mouse" orifice minus tunnel static) in inches of manometer liquid by q in inches of the same manometer liquid. "Mice" are inconvenient to use in that they require the tunnel to be shut down between measurements to permit relocation.

Other components of the airplane, such as wings (three-dimensional), tail surfaces, fuselages, etc., are adapted to pressure distribution tests by installing pressure tubes in a manner similar to that shown for the smooth surface models (cf. Fig. 2). Where this is impractical, the mouse method may be employed.

Mechanics of Pressure Distribution

Air flowing around an airfoil exerts a pressure at each point on the airfoil surface. This pressure is positive or negative, depending on whether it is greater or less than the static pressure of the air. A pressure distribution is merely a map of the pressures on an airfoil.

Consider an airfoil in a uniform stream, giving special consideration to some particular region on the airfoil, say on the nose. Let the region under consideration be an element of area of unit width and length, ds. Construct a tangent line through a section of the airfoil at the location under consideration, as shown in Fig. 7. The length, ds, lies on this tangent, and the force on the element is perpendicular to the tangent, as shown in Fig. 7. If p is the value of the net static pressure[3] on ds, then the force on the element has the value pds, which is noted as dF.

Further, if the tangent makes an angle A with the chord line as shown, then dF has components parallel and perpendicular to the chord line, and the values of these components are, respectively —

$$dF_x = dF \sin A$$
$$dF_y = dF \cos A \qquad (6)$$

From the triangle in Fig. 7 it can be seen that sin A $= dy/ds$ and cos A $= dx/ds$. Recalling that $dF = pds$, it follows that —

$$dF_x = p\,ds \times dy/ds = p\,dy$$
$$dF_y = p\,ds \times dx/ds = p\,dx \qquad (7)$$

The summation of *all the forces perpendicular to the chord line* along the x axis on both the upper and lower surfaces is called the *normal force*, and its value may be expressed in the general integral form —

$$F_y = \int p\,dx \qquad (8)$$

Similarly, the summation of *all the forces parallel to the chord line* along the y axis on both the upper and lower surfaces is called the *chord force*, and is given by —

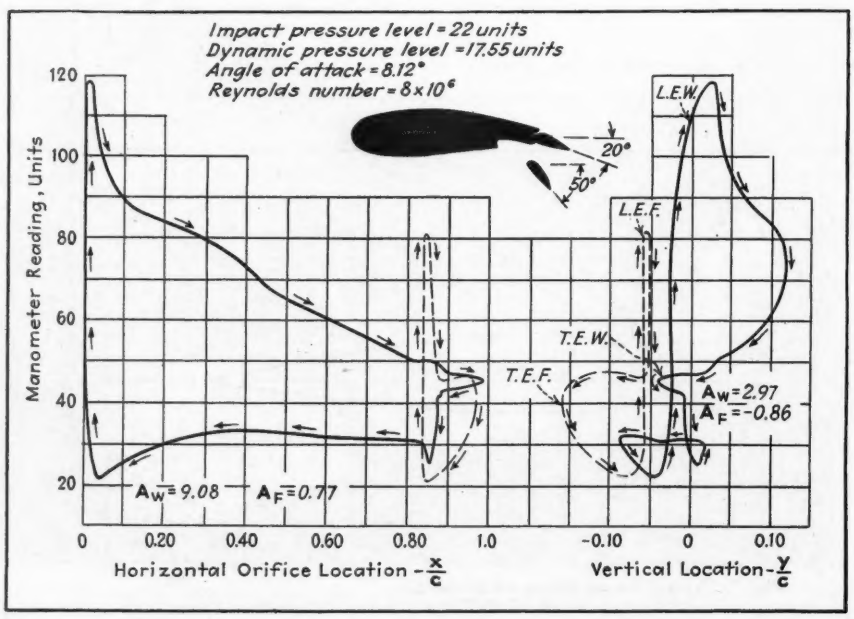
$$F_x = \int p\,dy \qquad (9)$$

These integrals are evaluated graphically from wind tunnel test data. For the normal force, the integration is carried out parallel to the chord line between the leading and trailing edges. Chord-force integration is carried out perpendicular to the chord line between the maximum upper and lower ordinates.

(*Turn to page 273*)

[3] By net static pressure, the concept of a pressure difference over free stream static pressure is implied, since only an applied pressure difference can produce a force. This is not to be confused with the difference in pressure between the upper and lower surfaces.

Fig. 9. Pressure distribution data.



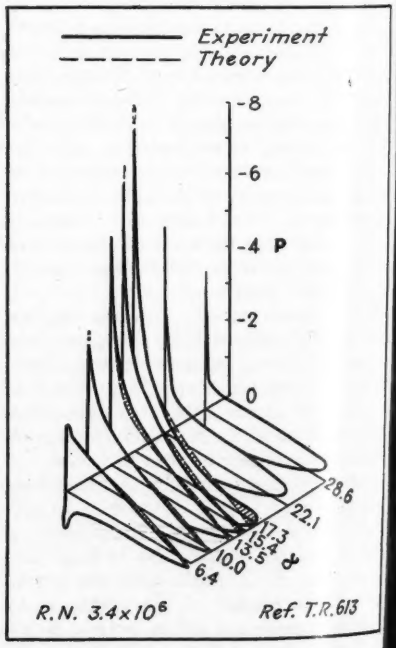
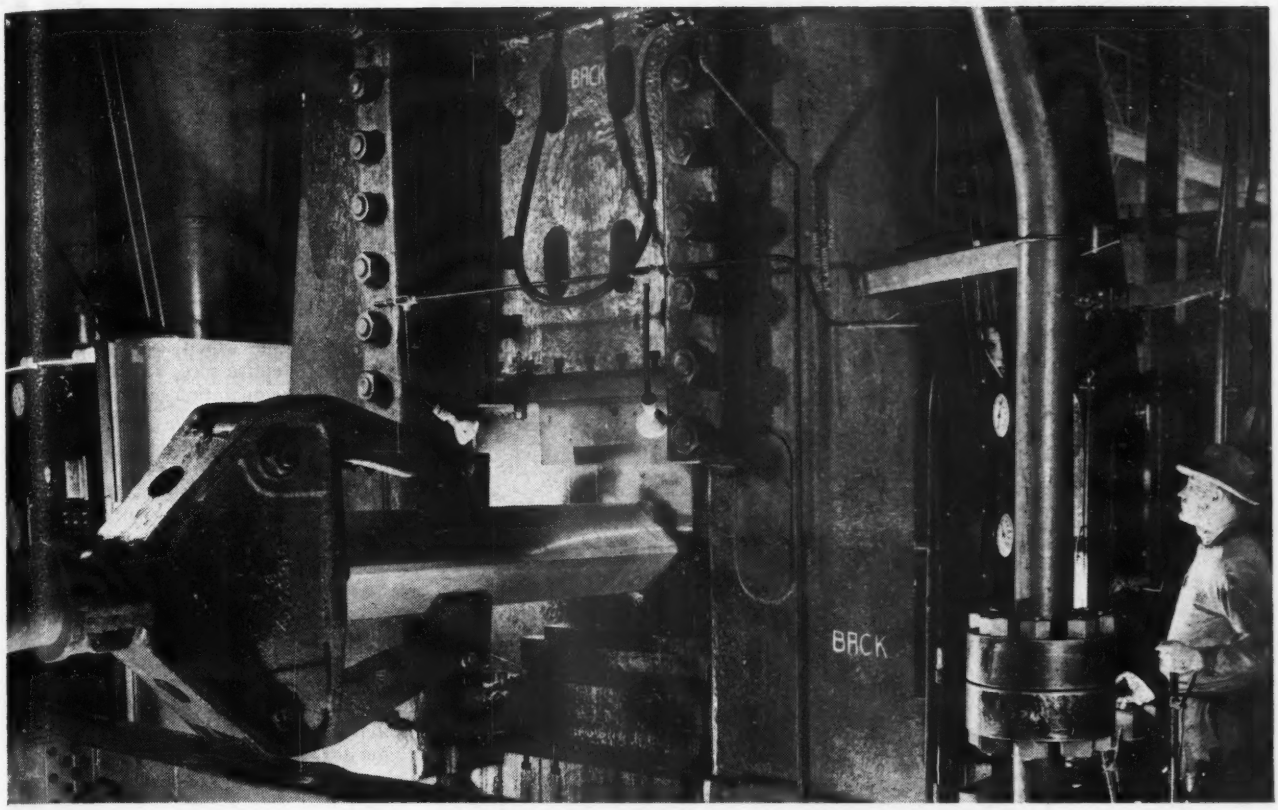


Fig. 10. Development of a stall, showing growth of separation.



Manipulator holding ingot in V jaws of 3,000-ton hydraulic press. By using V-shaped jaws, capacity of press has been greatly increased.

FROM BILLET TO BLADE

Chevrolet (no longer making cars) now cogs aluminum ingots into billets. And Frigidaire (no longer making iceboxes) completely processes these blanks into Hamilton Standard propellers. Here's the detailed "how" of this high-production wartime teamwork.

FROM START TO FINISH, the making of forged aluminum blades for Hamilton Standard propellers is a precision job. How difficult it is to make these airscrews and why they are so expensive will be considered in this article.

First off, there are two distinct phases in production—the rough forging from a billet and the machining to produce a finished product.

One of the outstanding aluminum forging plants in the country is that operated by Chevrolet, where aluminum ingots 1 ft. sq. and 9 ft. long are cogged down into the billets from which the smaller aircraft forgings can be made. The end product of these billets may, at this plant, be radial engine crankcases, aircraft parts, or the rough propeller blades in which we are interested.

From the forge plant, the rough blades go to Frigidaire. There they are completely machined, painted, and balanced ready for assembly. Frigidaire methods are doubly interesting because they show how a high unit production plant applied its methods and conveyors to making war products after conversion from refrigerators. The absence both of trucks and of men moving in the aisles instantly impresses any visitor. It is hard to realize that everyone is busy and that the plant is running at top production. All material is moved by overhead conveyors, so there is no reason for any worker to leave his machine.

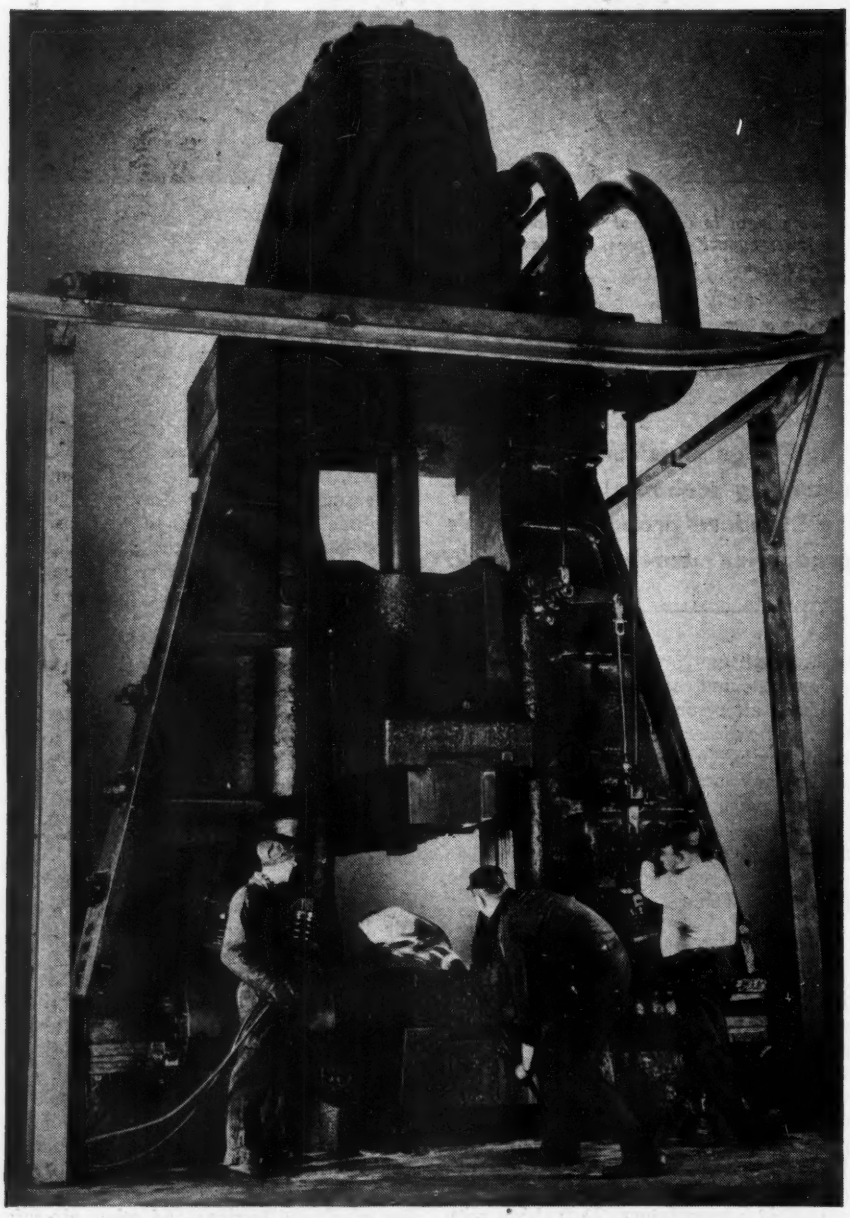
Forging Process

At the Chevrolet plant, one of the most interesting machines is the 3,000-ton capacity Wood hydraulic press. This press is operated by hydraulic pressure so that the aluminum is allowed to flow while being forged instead of being hammered. The ram operates under 4,500 psi. Two 300 hp. electric motors driving 100 gpm. triplex pumps are required to maintain this liquid pressure. Four air-over-fluid accumulators, 24 ft. high with 6¼ in. steel walls, hold the pressure. Each accumulator or "air bottle" weighs 32 tons. To maintain the air pressure, a triple stage compressor drawing 100 psi. shop-line air steps it up to 4,500 psi. It takes 48 hr. to charge the accumulators.

It is interesting to observe that the two 300-hp. water pumps can maintain the pressure while operating the press, but 4,500 hp. would be required continuously if the accumulators were not used. The tremendous pressure exerted when the press is in operation, heats up the hydraulic liquid so much that it has to be passed through a heat exchanger after release; 7,500 gal. of hydraulic fluid stored in three 28 ft. high and 4-ft. dia. tanks is required to cool fluid to the pumps.

When the press is in operation, the 1,500 lb. cast aluminum ingots are heated for 3½ hr. to 720 deg. F. in the adjacent furnace. Then each is picked up by the huge manipulator tongs and cogged down in the hydraulic press. In this operation, the tensile strength of the ingots, (about 39,000 psi.) is increased by the working of the metal to around 55,000 psi. A time-saving feature unique in this Chevrolet installation is mounting of the billet turntable on the front of manipulator bridge instead of on the floor. Cogged billets, cut up in sheet lengths, are used for crankcase sections and other aircraft parts.

Ajax rolls shape round stock into rough blades. Note different profiiles on roller for progressive steps in operation.



This 35,000-lb. steam hammer is used for finish-forging of blades.

One of the most interesting jobs at the forge plant is the volume production of aluminum propeller blades which *does not* involve the use of the Wood press. Four different models of blades are forged.

From 6 or 8 in. dia. aluminum billets, the right length of stock is cut off to provide sufficient material to form the size of blade being made. Belt-driven abrasive-wheel cut-off saws are used for this purpose.

Next the stock length of aluminum bar is centered on one end, then chucked in a Duomatic lathe which has two carriages so that the entire piece can be "scalped" to size in one operation by the tool on the near side while the tong "hold" is turned down by tools held on the carriage opposite. Stops are provided on the tool post so the "hold" end can be turned down in steps and no measurements have to be taken. This makes it easy for two men to turn out 20 units per hour.

The "scalped" billet is heated to 850 deg. F., then taken to a four step Ajax No. 5 roll swaging machine, where the round section of the billet is gradually flattened out. A progressive operation, this requires two men to handle the hot billet and a roll operator who knows just how far to feed the piece into the rolls at each stage.

After this, the semi-flattened piece is reheated and put under a 35,000 lb. Erie steam hammer. The blade is forged to size, and the flash is then removed by a special die mounted in a Bliss press beside the steam hammer.

At this point, "hold" on the shank is cut off with a Tannewitz band saw. Both the blade and the hold, which later becomes a laboratory test coupon, are stamped with identifying numbers. From this point on, the hold and blade go through the subsequent heat treating cycles together.

The shank is again heated preparatory to putting on the steel-roller thrust-bearing races and upsetting the end of the blade. This is an unusually ticklish job since there is so little clearance between the thrust rings and the jaws of the upsetting machines used to put the bulbous end on the blade shank.

With the forging complete, it is now necessary to heat treat to obtain maximum strength characteristics. The first step is the "solution treatment" for 12 hr. in an electric furnace, half of the time being required to bring the blades up to the soaking heat of 960 deg. F.

In 20 sec. or less after they come out of the electric furnace, they must be quenched in water. This "fixes" the metal structure obtained in the heat treatment. The tang cut off of each forging is wired to its blade and goes through exactly the same heat treatments as the blade itself. The blades are suspended from "merry-go-round" rings which allows compact, round-type electric furnaces to be used. This also assures the minimum blade distortion when quenched, for the water hits each side of the blade equally as it is immersed.

After quenching the blades have to

be aged. This is called "precipitation heat treatment". A Ross mechanized furnace 175 ft. in length is used for this purpose. The blades move about 2 in. per min. and take 16 hr. to complete a cycle through this furnace. About half the time is required to bring the blades up to the aging temperatures of 340 to 350 deg. F., then they are kept at this temperature for 8 to 8½ hr. This gives additional strength to the forged aluminum blade.

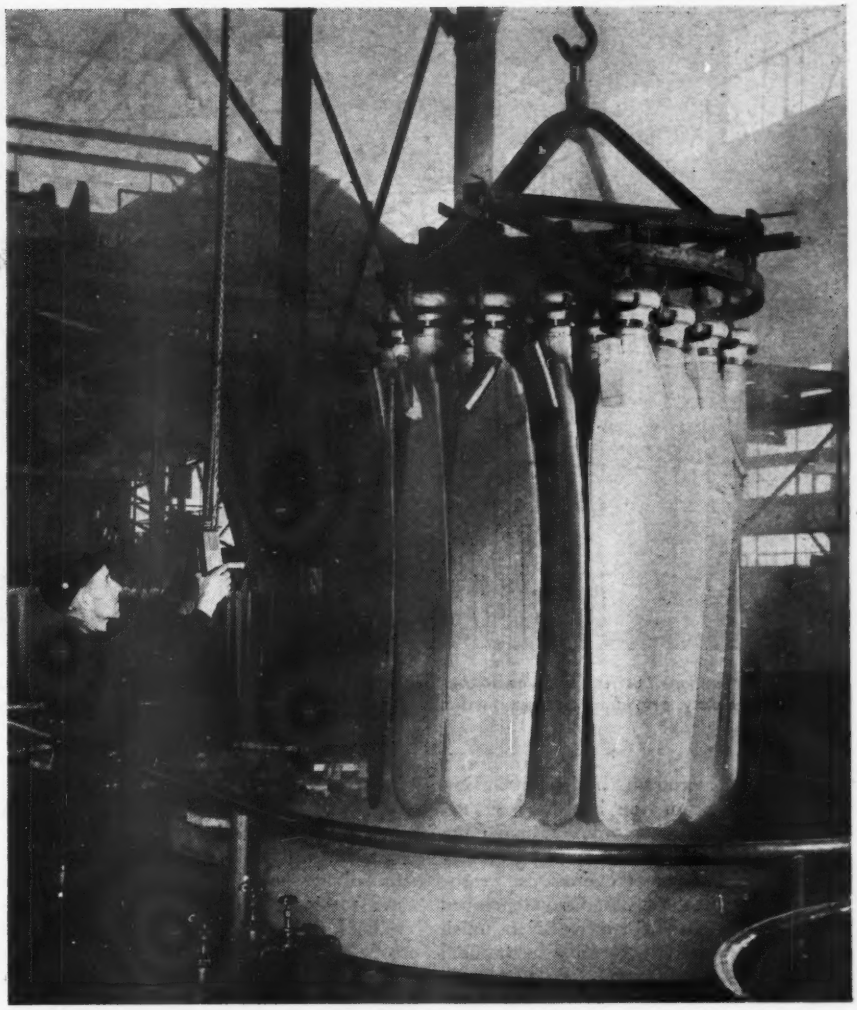
Inspection follows on each blade before it is shipped to the shop where it is to be machined. A tensile test specimen is turned from part of each tang. Another portion of the tang is analyzed chemically or with a spectroscope. With small bench lathes and tensile test machines, girls turn and test samples of every individual blade.

Forgings which pass inspection are now cleaned up with manual electric grinders, then inspected for visible mechanical flaws or dimensional variations before they are shipped away.

Machining at Frigidaire is the final step in production. Guided by years of experience in high unit production, this organization has developed new methods which have almost halved the man hours required per blade. Material handling has been reduced to minimum by utilizing the overhead conveyors formerly required in the manufacture of electric refrigerators.

The blade forgings are received from Chevrolet with the finished roller thrust-bearing races in place. These rings are carefully protected from damage in shipment, also during the machining of the blades, by a metal snap cover.

Before any machining is done, the bulbous end of the shank is tested for hardness. This is vital since this "upset" must carry the entire centrifugal and torsional loads on the blade. Therefore no machine time is lost by machining a blade which is unsafe. In its rough condition, a blade can be reheat-treated and probably saved—instead of scrapped as would be the case if any machine work were done on it while in the soft condition.

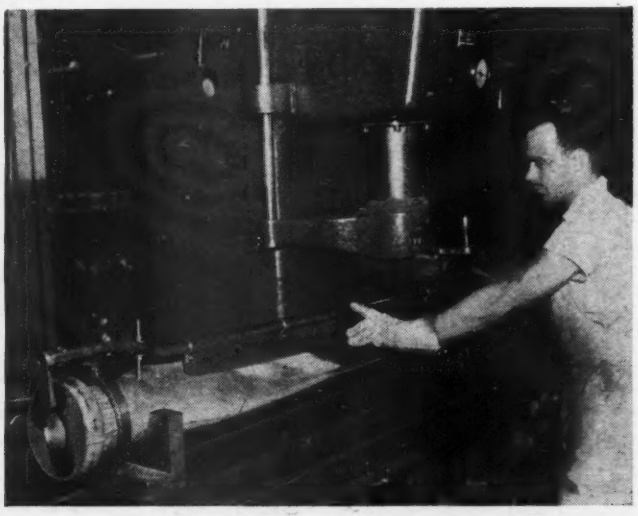


After shank ends have been upset they are heat treated and quenched in this tank. Note blade test samples wired to respective shanks from which they came.

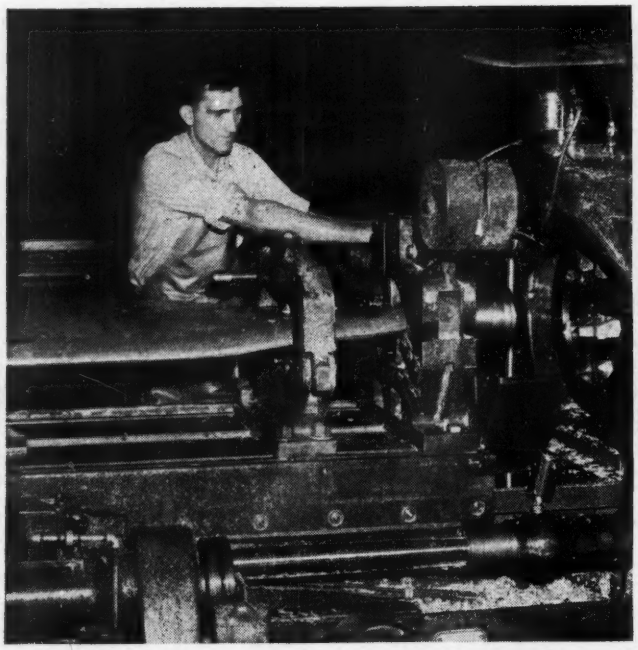
Equal care is taken to make sure the roller bearing faces have been unharmed during the blade upsetting or by the blade heat treatment which followed. This check is done on a special Magnaflux machine.

The first production operation is to put a center in the tip, then bend the blade to a template. Locating the blade by the tip center and the shank, the bottom end

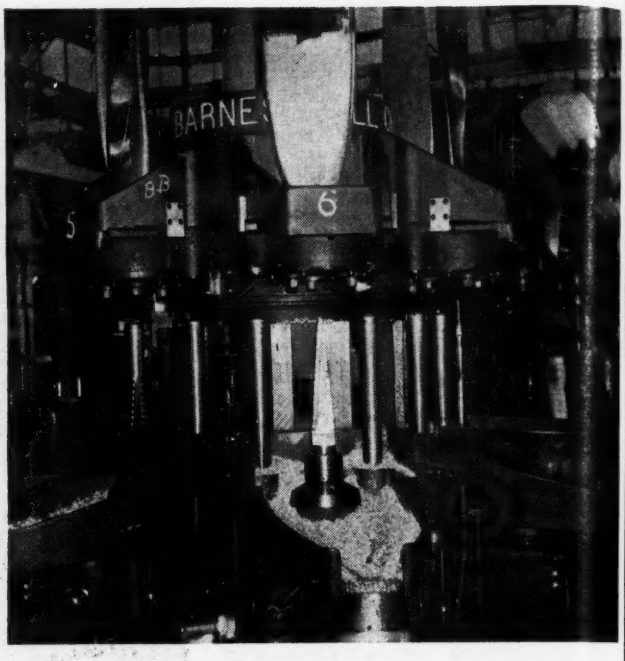
Dimensional checks are made to determine center line and to insure that sufficient material is included for all subsequent operations. (This and preceding photos by General Motors.)



Using center in tip and centerline on face, operator of straightening press uses template to check blade while bending it. (This and subsequent photos by Frigidaire.)



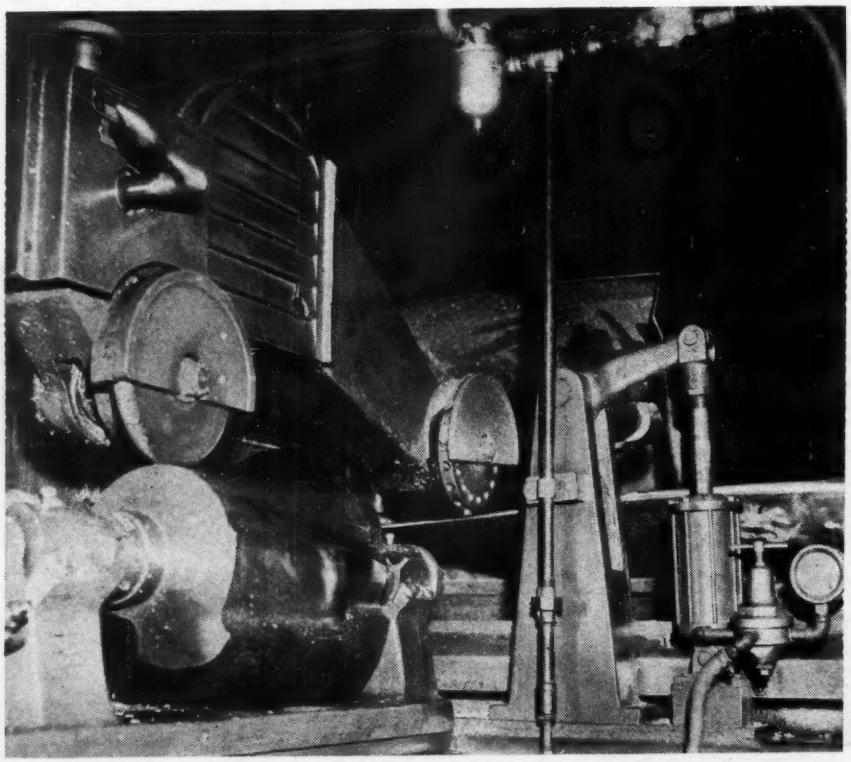
Blade shank has just been contour-milled in Hall planetary, providing first machined locating point.



Inverted drilling machine in which drills operate from below blades, permitting chips to fall clear by gravity.

of the blade is contour milled on a Hall Planetary—one of the big time savers, for it immediately provides a machining point on which the blade can be accurately located for subsequent operations.

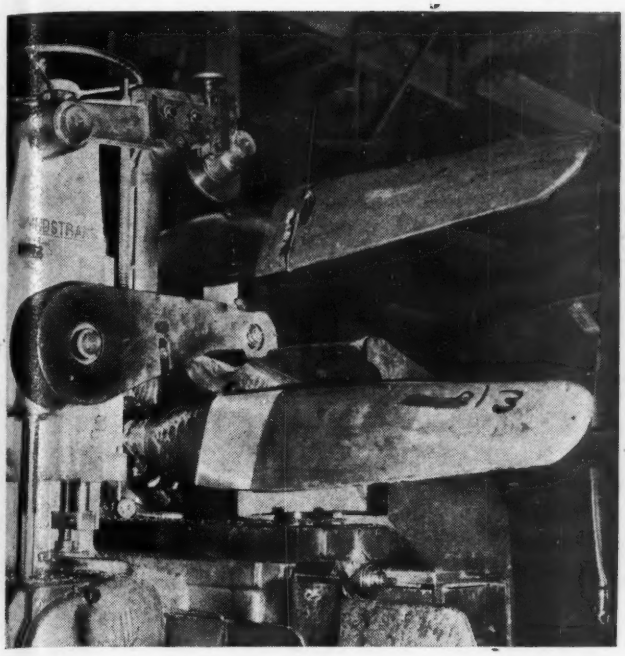
This is typical of the many machined operations, all of which work to finish the blade as nearly as possible to the final dimensions. With new type cutters and higher cutting speeds, Frigidaire has been able to machine blades closer and include parts that formerly had to be hand finished . . . Inspection was another difficult problem in man hours, so new and faster inspection fixtures were developed . . . Drafts and air currents from the heating and ventilating equipment caused much lost time and scrap on the blade balancing operations throughout the plant. Accordingly, blades are now balanced in a draft-preventer cage made from transparent plastic sheets . . . Automatic machines—one a mill for the blade tip, the other to mill the contour of the edges—have saved many man hours at a time when the company was "scraping the bottom of the barrel" for manpower.



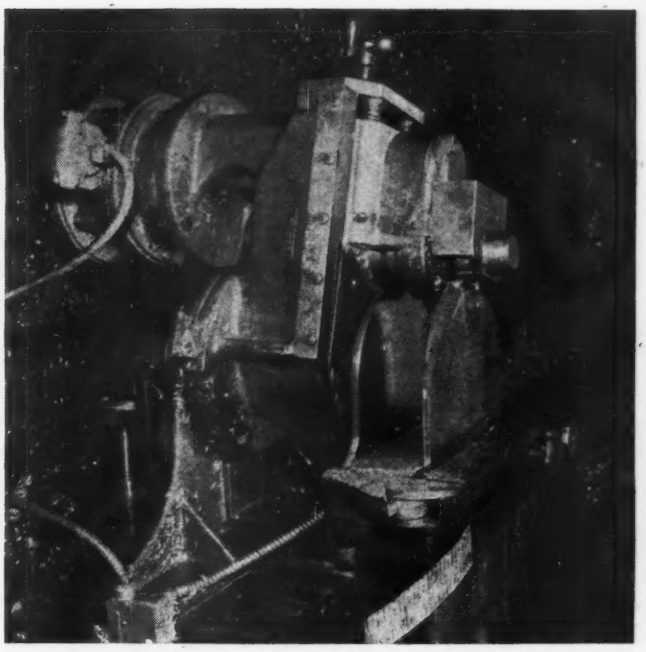
"Berliners," first invented in World War I for wooden props, are now used to finish faces of aluminum blades. Contour cam at left regulates depth of cut as blade is fed beneath revolving cutter at center.

Basically the operations in machining the blade are as follows: Inspection, finding of center line, and cutting center in tip, straightening if necessary to correct for warping during heat treating. There follows form-turning of the outside of blade shank and, with this locating the blade, boring of the deep tapered hole in the blade shank on a multiple spindle inverted drill (form drills that look like milling cutters are used for this purpose). Next the blade is put in a twister and given the correct angle if it has warped out of shape. The operator checks the blade while it is on a surface plate, marks it, then twists it more than required so as to allow for spring back. Again it is checked with a template to see that the blade is straight lengthwise.

After this preparation, machining starts on the face of the blade. From the tip to about the 36-in. station the face is machined with a Berliner. Then the blade goes to the copy mill and the blade and shank are machined all over, using a master blade as a guide. Direction of rotation and feed are reversed on this machine so the chips can be caught in the scoop and the cut started out on the blade instead of from the shank. By this method no portion of the blade to be machined is effected by warping, as is the case when the cut is started from the shank end. The cutter speed is doubled and only four carbide-tipped cutters are used (instead of a dozen or more) so



Copy mill turns both sides of blade from station 36 to shank. Master blade, guiding cutter, is at top; blade being processed is below.



Special contour mill shapes end of blade. Cutter at top is guided by cam directly below blade end.

as to get greater accuracy in the copy milling.

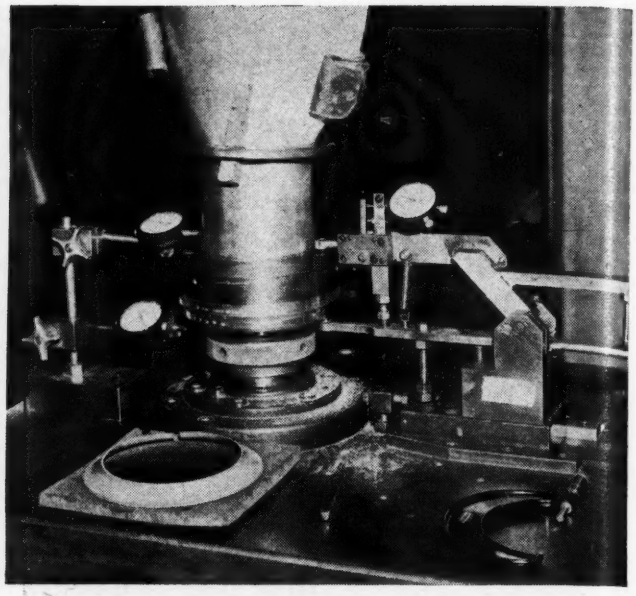
Now the face of the blade is hand ground to fit accurate templates and when finished provides a perfect foundation upon which to carry the blade while the camber side is machined on another Berliner.

Special mills have been designed to finish the top and sides of the blade. A Borematic finishes the shank radius and faces the bottom of the blade. A vertical lathe is used for hand dressing the contour between blade and shank. The camber side of the blade is now hand ground and blade is balanced at same time. Inspection for flaws follows. Blades are dipped in a caustic solution, washed, then dipped in an acid solution. After washing off the acid, any fine cracks or defects in the polished blade

Lapping off of machine marks and giving of final finish comprises most costly operation in blade making.

This hand operation blends machined shank and copy-milled portion of blade.

Airfoil inspection by vernier scale instruments, measuring angularity, width, and length within .001 in.



Gage for inspecting shanks of finished blades. Three dial indicators record measurements within .001 in.

will appear as black lines that can easily be detected by the inspectors.

After structure inspection, a final polish is given, and then a preliminary balance is made by inspectors. If the blade passes, it then goes to a four-spindle Ex-Cell-O and the locating holes are drilled and tapped in the bottom of the shank to secure the bronze bushing after it is inserted. The tapered hole in the shank of the blade is then bored out on the Borematic.

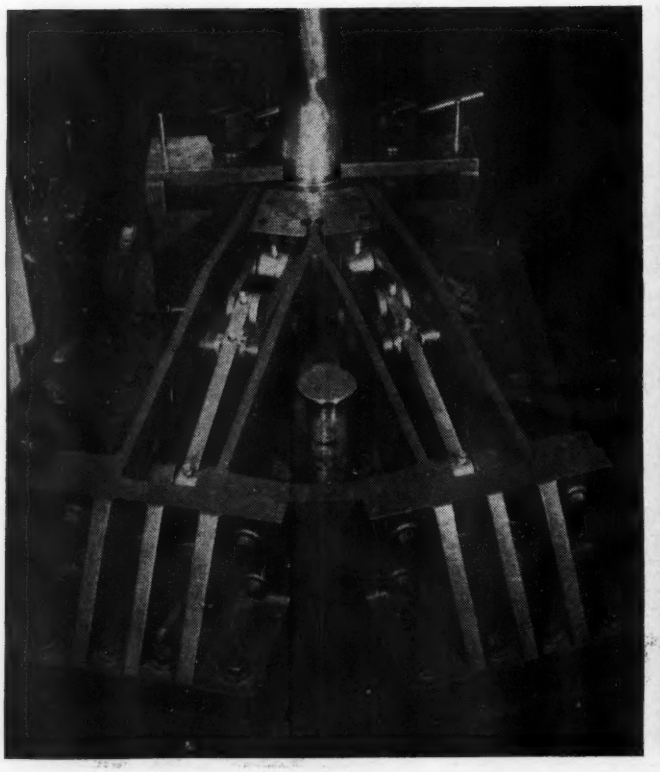
Next the end of the blade is carefully gaged, then the setting graduations are embossed on the edge of the shank flange.

Bushings are Frozen

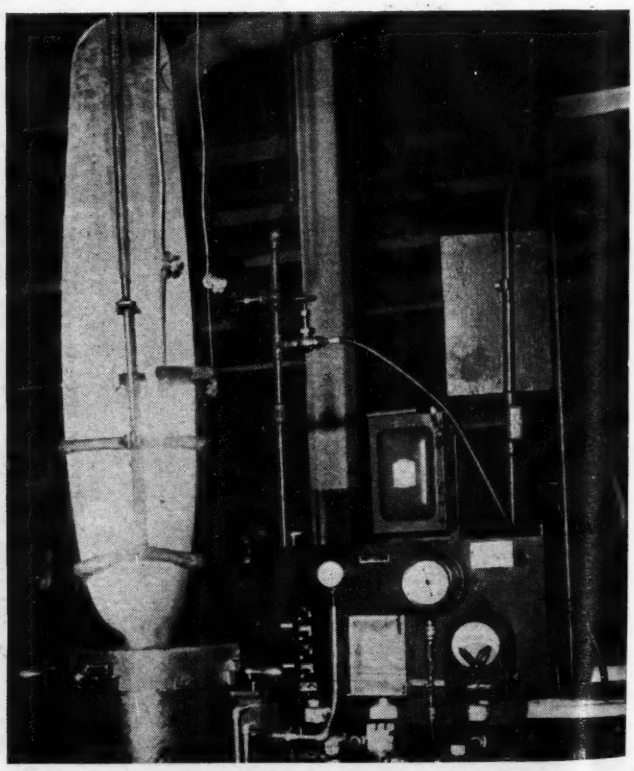
The bronze bushing which goes in the end of the finished blade is frozen to —20 deg. F. in a special Frigidaire commercial unit. The bushing is then pressed into the blade shank with 900-lb. pressure. Then the blade is ready for its accurate dimensional check on the very complete inspection fixtures provided.

A final buffing is given the blade to remove any minute scratches, due to handling, and it is then balanced with lead wool and degreased in an atmosphere of dichlorethylene. This eliminates water spots and provides a clean base upon which to apply the paint.

During the entire cleaning and painting process the blades are hung from a moving conveyor so no hands need touch the blade. Great care is required in painting, for a little overspray on the yellow tip is enough to change the balance of the blade.



Hydraulic toggle press which obviates engraving of scale graduations on shank. This method is faster and more accurate than engraving.



Toggle-type pneumatic hammer forces bronze bushing into shank. Bushing is frozen at —40 deg. F before pressing.

Approach to the Problem Of Radio Precipitation Static

PART II—NOISE REDUCTION

By **C. J. BREITWIESER**
Design Staff Engineer, Consolidated Vultee Aircraft Corp.

Concluding his two-part series on this troublesome phenomenon, the author discusses present methods of noise reduction and the probable final solution to improve radio communications.

IN APRIL AVIATION we concluded that the apparent discrepencies of the phenomenon of precipitation-static are explained by the differences of the electrical conditions of the atmosphere. Contradictions to the current hypotheses seem to take place at a time when the airplane is flying through a region of appreciable electric gradient and may be rationalized by giving proper attention to the gradient field effects.

The methods of reducing radio interference of this nature may be grouped into two classes: (1) Treatment of the airplane, and (2) treatment of the radio apparatus.

Two general methods of treatment may be applied to the airplane: (a) The surface and exterior of the plane may be so treated as to minimize the rate of accumulation; (b) the airplane may be treated with devices to minimize the effects of the charge once it has accumulated.

Minimization of Charging Rate

First and most direct method of minimizing the accumulation of electric charge is to reduce airplane speed. The greater the velocity of impinging particles of precipitation, the greater the number of electrons knocked off with a subsequent increase in the charging effect. Reducing the speed greatly reduces the effect of precipitation-static. Not all pilots seem to be familiar with this fact, but, regardless of the other measures which are applied, the speed should be reduced. Reduction of propeller speed also decreases the amount of interference. The radio noise may be lessened by reducing the engine rpm.; the pitch of the propeller may be increased to compensate for the reduced rpm.

A second method of reducing the accumulated charge is to treat the surface of the aircraft. A smooth surface with a minimum of projections and irregularities has a lower charging rate than a rough surface. Certain type finishes have been observed in wind-tunnel tests to have a marked effect on the charging rate. In a Consolidated Vultee test, one type of airplane dope on the metallic surface of the model resulted in a charging rate of four times that of another type of paint. It was also observed that for certain types of dust, one paint would cause a charge of negative polarity to build up, whereas another paint would cause a positive charge.

Observations of this nature indicate that there is considerable value in the treatment of the surfaces. Investigations have not proceeded far enough as yet to make any specific recommendations at this time; however, it is not outside the realm of possibility that the precipitation-static interference may be substantially reduced by the application of a thin layer of paint of some specific composition.

Control of Discharge

Once the charge has accumulated on the airplane, it will build up to a potential at which some region of high electrical gradient experiences local ionization and the charge drains off. As explained before, this will cause radio interference unless some method is provided for controlling it.

Most direct approach is to smooth all projections and sharp edges on the air-

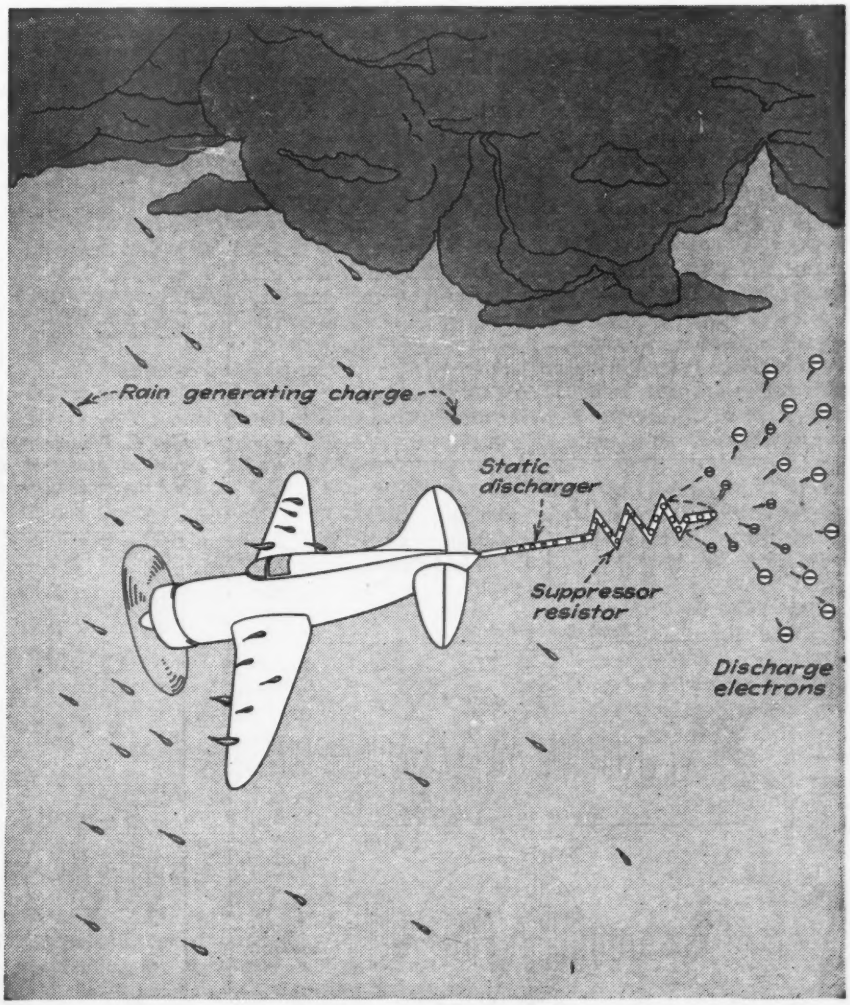


Fig. 3. Precipitation static discharger.

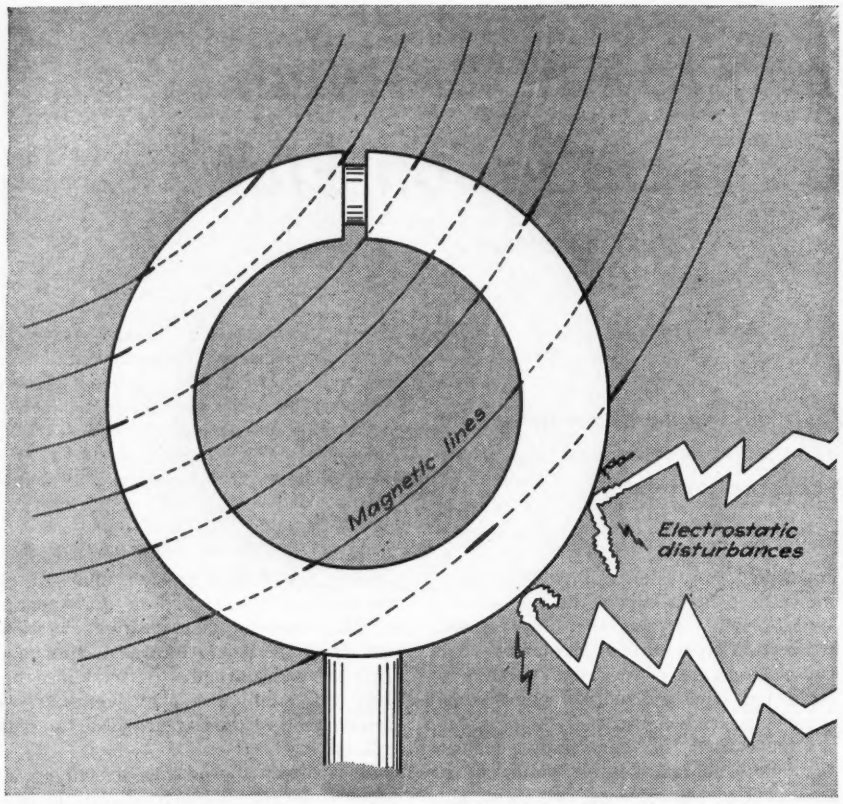


Fig. 4. Shielded loop antenna, most generally used on aircraft for noise reduction.

plane and provide one or two sharp points so that, as the charge builds up, these points will create a critical electrical gradient before any other place on the airplane, and the ionization and discharge will be localized.

Once the discharge is localized, some measure of control may be applied. The simplest method is to use a long, thin trailing wire with a series resistor (Fig. 3. Also see Part I, April). The trailing wire extends the sharp point (at which the discharge takes place) some distance to the rear of the plane. The series resistor acts in the manner of a spark plug suppressor on an engine and reduces the severity and duration of the noise pulses.

The series resistor may act as either a true oscillation suppression resistor or as a decoupling resistor, depending on the manner in which it is applied. As a decoupler (usually of short length), it serves to isolate the discharge circuit (trailing wire, in this case) from the inductance and capacity effects of the airplane. As a suppresser (usually of considerable distributed length), it serves to increase the circuit decrement and add resistance to the spark-excited circuit so that it will no longer be self-resonating.

Many other devices have been used to control the discharge. Various forms of trailing wires and static discharge spikes and rods make their appearance from time to time. A successful discharger does either one of two things, or both. It localizes the discharge and suppresses the radio interference or it converts the discharge into a type of discharge which has a minimum effect on the radio receivers.

Such devices as the radium-tipped discharge rod, ultra-violet generator, high polarizing potentials on the discharger, and creation of secondary particles for charge transportation have all been considered. Several modifications of these are, at present, being developed and show signs of being considerably more effective than the trailing wire. The *modus operandi* of each is to drain the accumulated charge from the airplane in such manner as to cause a minimum of radio-frequency electro-magnetic disturbance.

Another approach to the problem is in the design and treatment of the radio apparatus. There are certain systems of

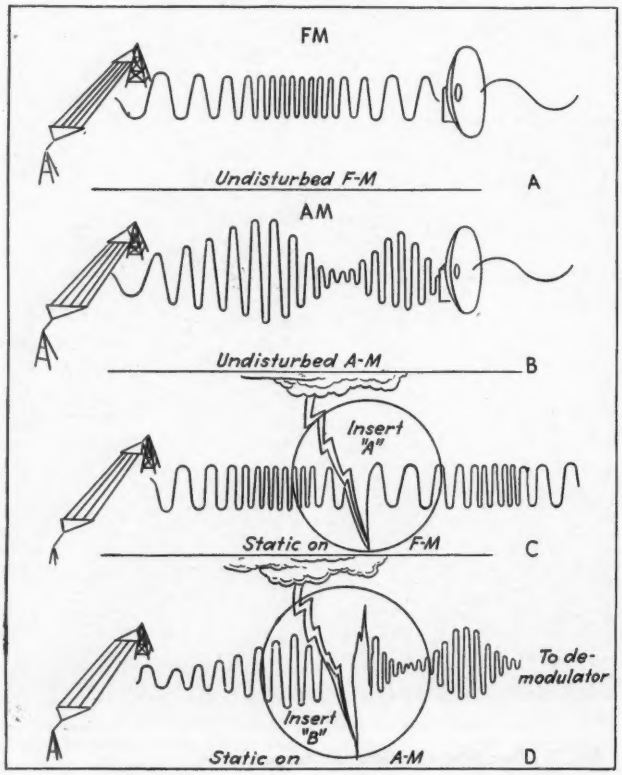
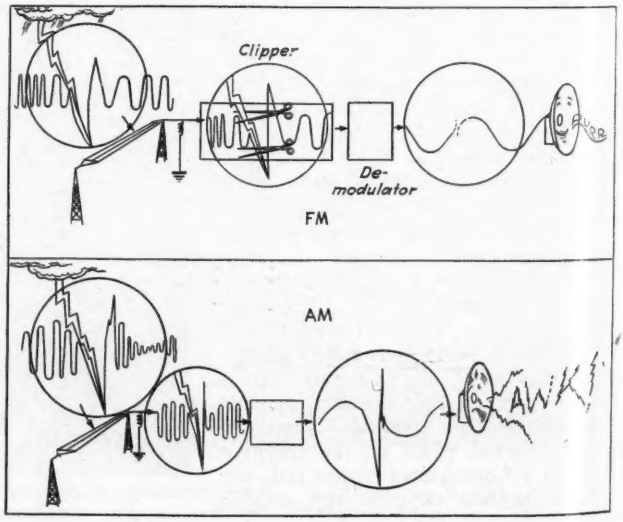


Fig. 5. Comparison of sensitivity of frequency-modulation and conventional amplitude-modulated systems under undisturbed and disturbed conditions.

Fig. 6. Diagram showing how receiver picks up "disturbed" transmissions over F-M and A-M systems. Static affects amplitude but not fundamental frequency.



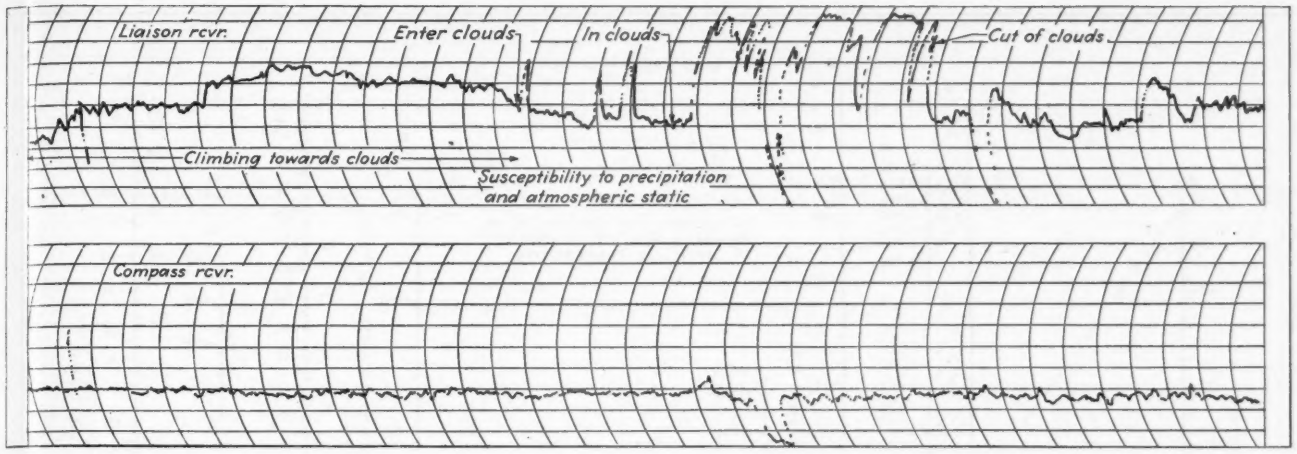


Fig. 7. Simultaneous recording of noise level output on a receiver using a conventional single-wire antenna and a receiver with shielded loop (compass type).

radio transmission and reception which are inherently less sensitive to outside disturbances than others and may be used in aircraft to minimize the effect of static.

Frequency-Modulation

Frequency-modulation systems are many times less sensitive than the conventional amplitude-modulated systems. Unfortunately, most aircraft systems of today are amplitude-modulated, a system which is about the worst offender of all.

Not all F-M systems are equally insensitive; the so-called "wide-band" gives the greatest reduction in noise.[5] Expressed crudely, atmospherics or outside electrical disturbances are capable of inflicting *amplitude* or *magnitude* changes in a transmitted radio wave, but they are unable to change the *wave length* of the transmitted wave, since that is solely a function of the transmitter components. An A-M receiver is sensitive to changes in signal level or intensity and therefore sensitive to static disturbances. On the other hand, the F-M receiver will respond only to deviations in frequency and therefore does not respond to static.

An F-M radio wave transmits the "intelligence" by means of the variations in the carrier frequency. Note in Fig. 5A the essentially constant amplitude of the F-M wave and the variation in the frequency. In Fig. 5B it may be noted that the fundamental frequency is essentially constant, but the amplitude of the signal is varied in direct ratio with the transmitted "intelligence."

In Figs. 5C and 5D, static mainly affects the amplitude but not the fundamental frequency. These "disturbed" transmissions are picked up by the receiver as shown in Fig. 6.

The F-M receiver has a so-called "clipper" stage which removes the effects of any variation in amplitude and, consequently, the received "intelligence" is demodulated and reproduced at the loudspeaker with practically no distortion from the static.

The A-M (amplitude-receiver), on the other hand, depends upon the variations in amplitude of the received wave for the reproduction of the transmitted intelligence. Therefore, any amplitude distortion of the transmitted wave will be impressed on the demodulator stage and will manifest itself as distortion or noise in the loud-speaker.

One of the limiting factors of present-day F-M systems is the fact that it is a wide-band system and, therefore, necessarily is confined to the short wave lengths where these wide channels are available. Nevertheless, F-M is creeping into more and more aircraft radio applications and is a great improvement over the present A-M as far as precipitation-static is concerned.

Noise Reduction Antenna

Radio interference of external origin may be substantially reduced by a correctly designed antenna. A long antenna will pick up more noise as well as more signal. The signal-to-noise ratio may be increased by using an antenna of critical length, or one which is tuned to the particular wave length in question.

There are several forms of so-called noise reduction antennas. These types of antenna are generally for the reception of one particular wave length or band of wave lengths, and only to the extent to which the radio equipment in question is to be used in this manner is this type of antenna of any value. A trailing wire which may be reeled in and out to any specific length is frequently used in aircraft radio.

In the case of precipitation-static, the advantage of a tuned antenna is offset by the fact that the trailing wire acts in a manner similar to that of the static discharge wire and thus pipes noise directly into the receiver. Tuned doublet and other similar types of noise reduction antennas are, in general, impractical for the installation on an airplane.

Loop Antenna

By far the most universally used antenna for noise reduction on aircraft is the shielded loop or "anti-rain static loop," as it is called by some manufacturers (Fig. 4).

This antenna consists of a loop antenna which is completely enclosed in a metal sheath or housing, save for one small segment or slot to prevent the shield from forming a closed loop. The shield is made of a nonmagnetic material.

Since the shield is not completely closed, the loop is responsive to the magnetic field. All but the section at the narrow slot is completely enclosed and electrostatically shielded. A quite complete description of the shielding action is given in Dr. Starr's paper (see references, Part I, Apr. AVIATION).

Largest component of precipitation-static noise is in the electric field vector and therefore is markedly reduced by an "anti-rain static" loop. Due to the fact that the electric current flowing from a static discharger is low and the voltage is high, a relatively large amount of the discharger noise field is propagated as an electric field, and a relatively low portion is magnetic. The magnetic field is not propagated to any appreciable extent and the electric component is shielded by the electrostatic shield of the loop. Therefore, the loop antenna used in conjunction with the discharger has been found quite effective in reducing the effects of precipitation-static.

The conventional single-wire antenna is quite susceptible to the precipitation type of disturbance. Fig. 7 is a simultaneous recording of the noise level output on a receiver using a conventional single-wire antenna and a receiver with a shielded loop (compass type). It is interesting to note how the noise level on the conventional receiver built up as the clouds were approached and dropped off suddenly as the airplane left the clouds. The receiver with the shielded loop gave only a slight increase in noise at the most severe region, as may be noted from the recording which remained at essentially a constant low level.

Fig. 7 is on a db scale; the top of the chart represents a saturated condition. The second scale division from the bottom of the chart represents approximately a threshold level of sound under the condition of the airplane's ambient noise.

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[5] Hund, August—**Frequency-Modulation (book)**, McGraw-Hill.

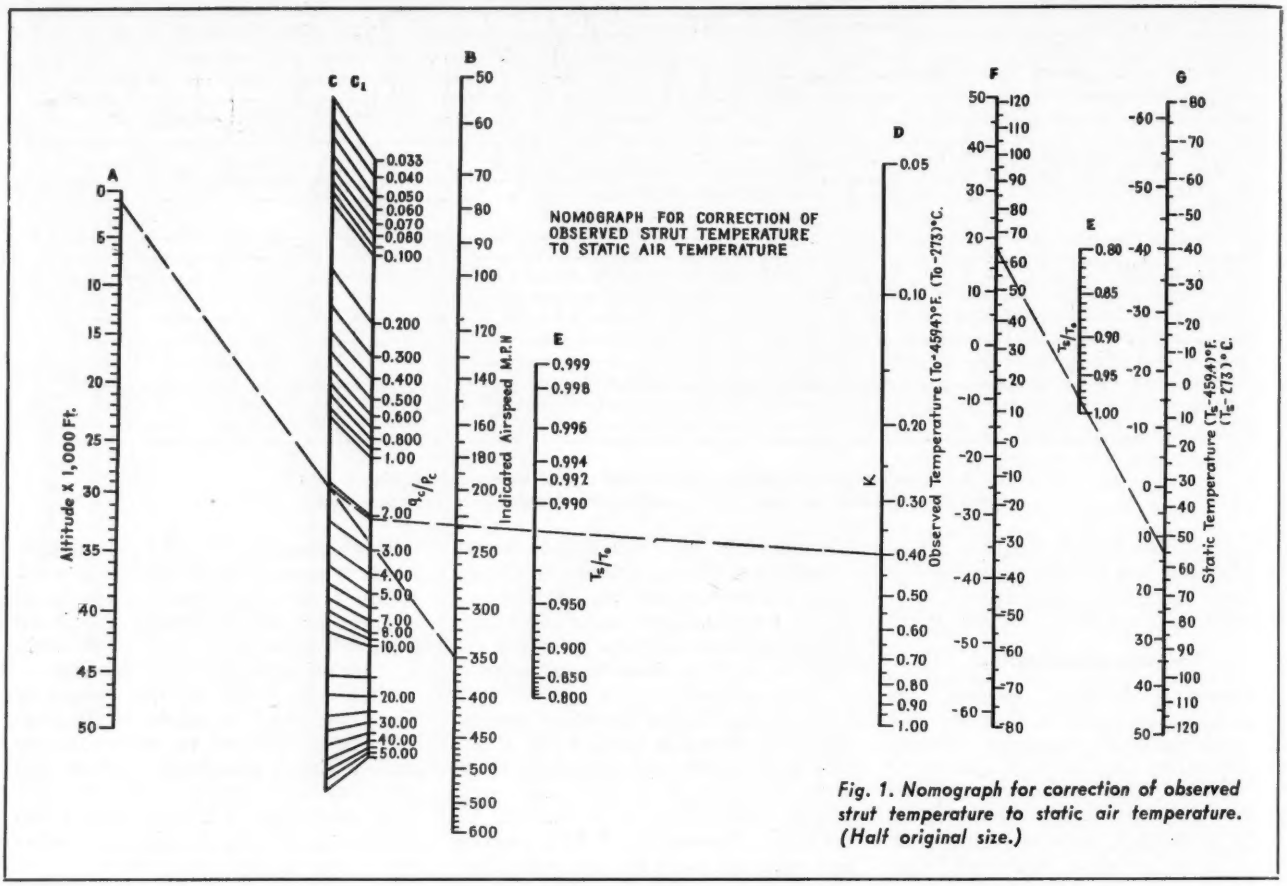


Fig. 1. Nomograph for correction of observed strut temperature to static air temperature. (Half original size.)

Graphic Simplifications In Computing True Airspeed

By RICHARD G. SMITH, *Experimental Flight Engineer, Pratt & Whitney Div. United Aircraft Corp.*

Presenting pertinent nomographs which not only save much valuable time in estimating true airspeed but also go far in reducing chances of error in calculations.

TRUE AIRSPEED, the velocity of aircraft relative to the air, may be computed as the product of *indicated airspeed,* a *compressibility correction factor,* and the *square root of the density ratio.*

First, for the sake of clarity, it would be well to discuss the significance of each of these terms:

By *indicated airspeed* is meant the reading of a perfectly constructed airspeed meter subjected to the true dynamic pressure of the air. Practically, it is the airspeed meter reading corrected for errors due to the instrument itself and to an imperfect location of the pitot-static head.

Airspeed meters are so graduated as to read true airspeed if subjected to true dynamic pressure under standard-air sea-level conditions of air pressure and temperature. Any departure from these conditions affects the reading of the airspeed meter in two ways—

First, due to the increased compressibility of the air at higher altitudes, the dynamic pressure for a given true airspeed would increase if the air density were to remain unchanged. The airspeed meter reading, or indicated airspeed, would then become higher than the true airspeed. Thus the need for a "compressibility correction factor."

Second, as the altitude is increased the air density must actually decrease. This has the effect of reducing the dynamic pressure for a given true airspeed. The indicated airspeed, after being corrected for compressibility changes, is multiplied by the square root of the density ratio to obtain true airspeed. This density ratio is equal to standard air sea-level density divided by the density of the air at the altitude in question. Inasmuch as air density is fixed by air pressure and temperature, it follows that the square root of the density ratio is a function of pressure altitude and free air temperature.

Unfortunately, any temperature-measuring device as installed on an aircraft does not measure static free-air temperature. This is because as the thermometer strikes the air, the air is compressed and its temperature is raised. It is necessary to correct for this temperature rise before the square root of the density ratio can be accurately determined. This correction can most conveniently be made by use of the accompanying nomograph (Fig. 1). Pressure altitude and indicated airspeed are aligned on scales A and B. The value obtained on scale C is transferred to scale C_1, then aligned with the proper value of K (next page) on scale D. The temperature ratio found on scale E is transferred to scale E_1 and aligned with the observed temperature on scale F. Corrected temperature is then found on scale G.

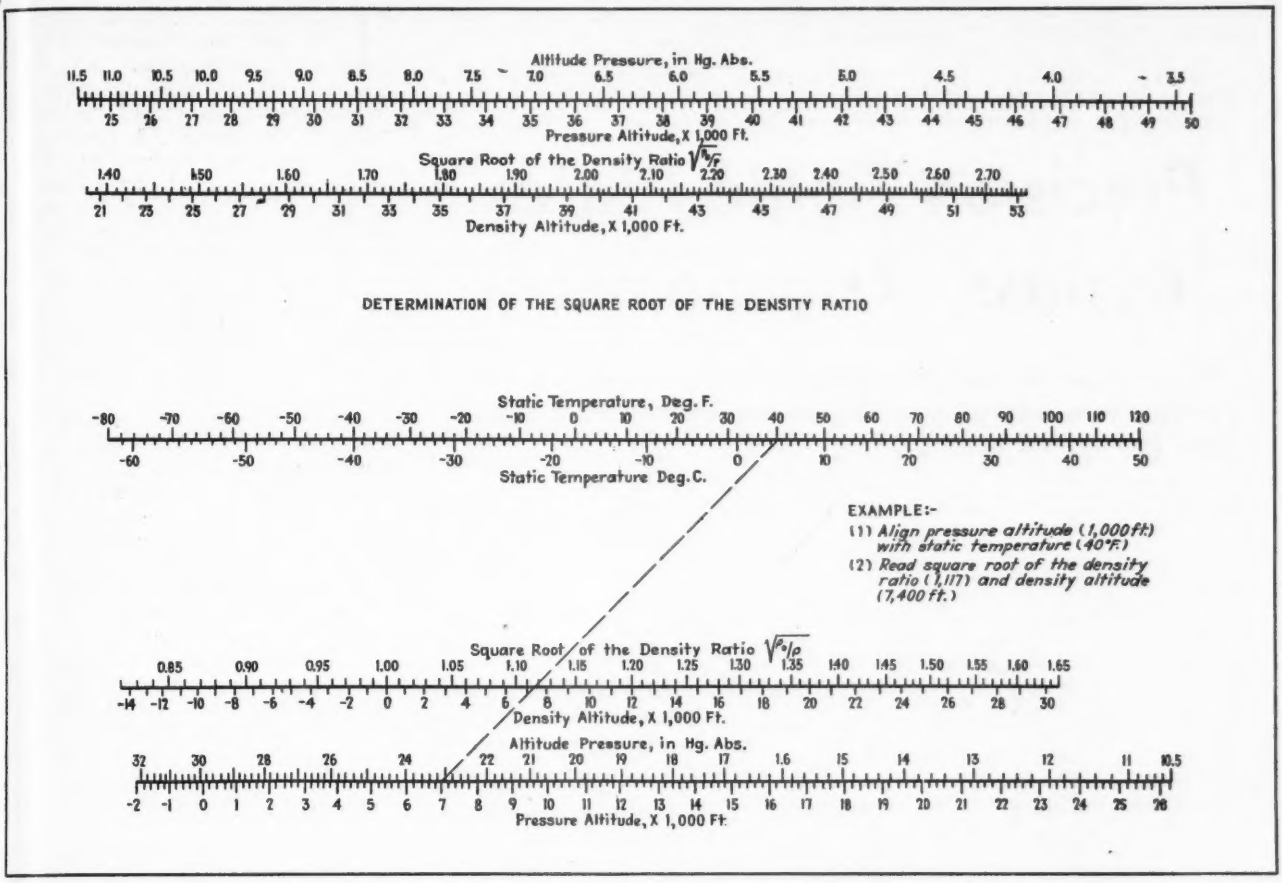

Altitude Pressure, in Hg. Abs.
Pressure Altitude, X 1,000 Ft.
Square Root of the Density Ratio
Density Altitude, X 1,000 Ft.
DETERMINATION OF THE SQUARE ROOT OF THE DENSITY RATIO
Static Temperature, Deg. F.
Static Temperature Deg. C.
EXAMPLE:-
(1) Align pressure altitude (1,000 ft.) with static temperature (40°F.)
(2) Read square root of the density ratio (1,117) and density altitude (7,400 ft.)
Square Root of the Density Ratio
Density Altitude, X 1,000 Ft.
Altitude Pressure, in Hg. Abs.
Pressure Altitude, X 1,000 Ft.

Fig. 2. Determination of square root of density ratio. (Reduced to 0.4 original size.)

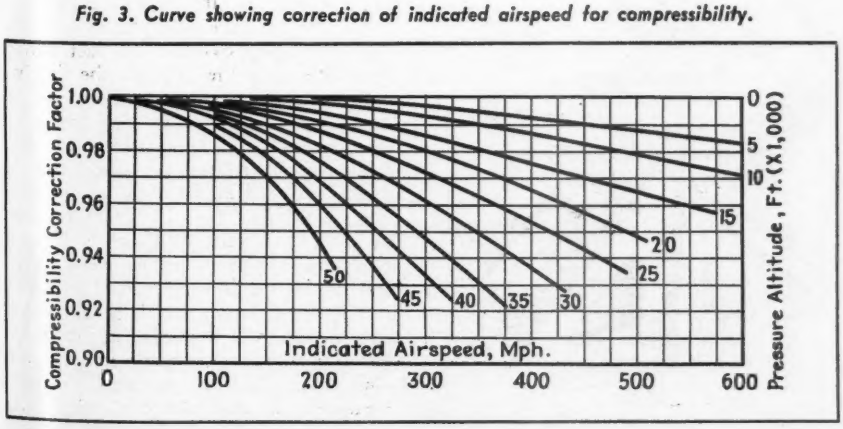
Employing this corrected temperature and the pressure altitude, the square root of the density ratio may be found on the corresponding (Fig. 2) nomograph. The compressibility correction factor is read from Fig. 3, and the true airspeed is then a simple slide-rule computation: Indicated airspeed × compressibility correction factor × square root of the density ratio.

Value of K

The value of K depends upon the location and type of temperature-measuring device used. It is a value which may be accurately determined from speed-course calibration data by plotting the observed strut temperature versus true airspeed for the calibration runs. Runs should all be made at the same altitude and in as short a time as possible, preferably in one flight, so as to minimize changes in the static air temperature. The curve obtained may be extrapolated to zero airspeed to determine the static air temperature. For each run, the temperature correction (= observed temperature — static temperature) may then be plotted against true airspeed. Comparison of this curve with Fig. 4 will yield the value of K (= actual temperature rise + adiabatic temperature rise). K ordinarily ranges from 0.5 to 0.8, and an average value of 0.65 may be used

(*Turn to page* 273)

Fig. 3. Curve showing correction of indicated airspeed for compressibility.



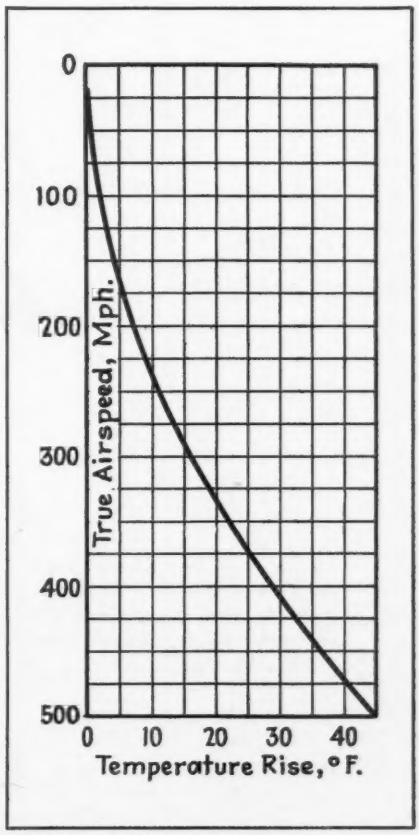


Fig. 4. Curve showing adiabatic air temperature rise due to impact.

Precision Angle Plates "Bypass" Trigonometry

Obviating use of math for laying out compound angles, dial angle plates employed by Curtiss-Wright save many hours and give instant accuracy.

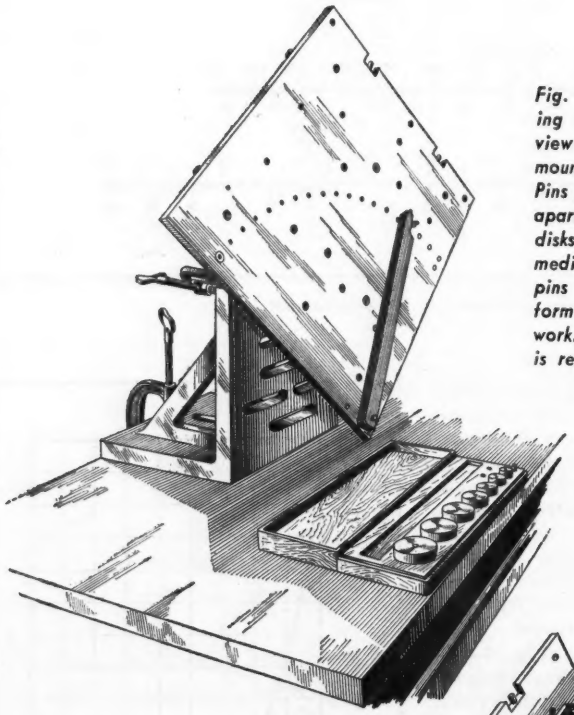


Fig. 1. Dial angle plate for measuring compound angles. This front view shows plate with sine bar mounted on pin at lower corner. Pins placed in holes spaced 5 deg. apart give angular spacing, and disks (in case) are used for intermediate measurements. Permanent pins in notches on edge of plate form sine bar for simple layout work. No knowledge of mathematics is required to use this instrument.

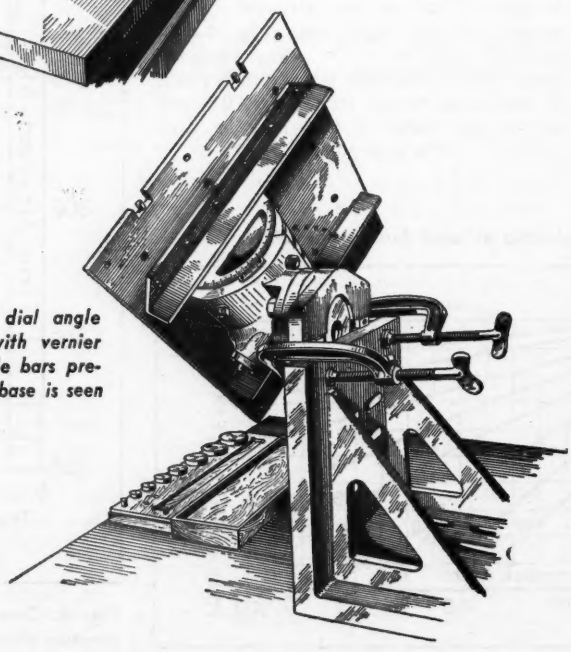


Fig. 2. Rear view of dial angle plate, showing knee with vernier scale. Reinforcing angle bars prevent warping. Rotary base is seen between clamps.

THE PROCESS of laying out and checking jobs where compound angles are involved, has been made simpler and shorter by the dial angle plate, an instrument (Figs. 1 and 2) designed by Harry B. Comfort and Charles F. Palm, foremen in Curtiss-Wright's tool inspection department. The plate—actually a dial for a 90 deg. arc—is used in conjunction with a toolmaker's knee with a vernier scale. This knee, maneuverable from a vertical to a horizontal position, has a rotary base and furnishes but one angle. By applying the angle plate to the knee, compound angles can be obtained in a range sufficient for all practical applications.

Measurement by means of the new instrument results in better workmanship, while a number of attachments make it easy to apply in complicated jobs. It can be used by inexperienced workers for precision angle checking, either simple or compound, since the angles can be measured in degrees, minutes, and seconds.

The plate may be made in any convenient size desired, and to date both a 10x12 in. and a 20x14 in. plate have been designed. Construction of the instrument and its accessories is simple. A series of plotting holes are drilled in a $\frac{1}{2}$ or $\frac{3}{4}$ cold rolled steel plate. Slip fit dowel pins, a set of graduated disks, centrally drilled, and a pivot sine bar comprise the accessories.

Two feathers on the back surface, parallel to the fore edge, and four lock bars lock the plate in any position on the knee. Holes provide for angle measurement in a 90-deg. arc by insertion of slip-fit pins in combination with a sine bar. Three holes on a straight line along the base and two holes along the right edge form a 90-deg. angle. The hole at the angle gives a center of an arc formed by 19 holes drilled in the plate on a 15 in. radius and spaced 5 deg. apart. Additional holes are provided for other angle combinations. All holes are reamed .25 in.

A sine bar pivots on the corner hole to contact a fit-pin inserted at any desired point on the arc, thus determining that particular angle. Minutes of angle are obtained by slipping disks over the pins graduated in sizes from $\frac{1}{4}$ to $4\frac{3}{4}$ deg. A further breakdown in seconds can be made by using gage pins with the disks—the pin heads also in graduated sizes.

A feature of the sine bar is an obtuse angle notch on the index end with a slight circular relief provided at the angle. This cut-out provides a contact surface for the pins or the disks on the sine bar.

A simplified sine bar, which can be applied in checking compound angles not easily measured with standard sine bars, is another instrument for angle measurement developed in the plant's tool inspection department (see Fig. 3). Designed by Tool Inspector William F. Schulte, it has proved itself highly useful in tool and fixture manufacturing and inspection.

The instrument is a cylindrical rod with concentric ball bearings at the ends. In using it where an angle is not readily obtainable, there is no need for extra measurements and additional calculations,

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INCREASES SAFETY
REDUCES MAINTENANCE

WHEN self-sealing rubber fuel cells were developed, their prime purpose was to protect against fuel leakage and fire caused by bullets. However, it was soon discovered that these rubber cells had another important advantage over the integral-type compartments formerly used—they gave considerable protection against other types of leakage. For example, in minor crashes, these rubber cells would resist shocks which could buckle and split open an integral fuel compartment.

This discovery suggested the use of rubber fuel cells as a solution to the fuel-leakage problems in non-combatant aircraft. It wasn't necessary to carry the extra thickness and special construction of the bullet-sealing cell to give airplane designers the other advantages of rubber containers. The lightweight B. F. Goodrich "bladder-type"cell meets the need for a flexible, leak-proof, non-self-sealing rubber unit. These B. F. Goodrich cells are actually rubber bags or bladders tailored to fit accurately into the spaces between wing supports. Each cell is equipped with fittings for filling and draining.

Integral-type compartments, on the other hand, are simply calked-off sections of the wings with connecting channels through which the fuel flows. Thus, the skin of the wing is actually the outside of the fuel tank, with every rivet and seam a potential source of leakage. Even in rigid wings there is constant strain on these metal junctions. This strain, plus changing temperature, in time may cause rivets and seams to loosen. Although this loosening does not weaken wings structurally, it can result in considerable fuel leakage.

When this occurs, much needed fuel is lost in flight. As a result planes are grounded and flight schedules disrupted. And repair costs are high because the source of the leak is often hard to find and hard to repair.

B. F. Goodrich "bladder-type" cells meet these problems and offer other advantages. They can be made in many sizes and shapes. Being flexible, they're easily installed and removed. No calking is necessary, thus saving an expensive building operation.

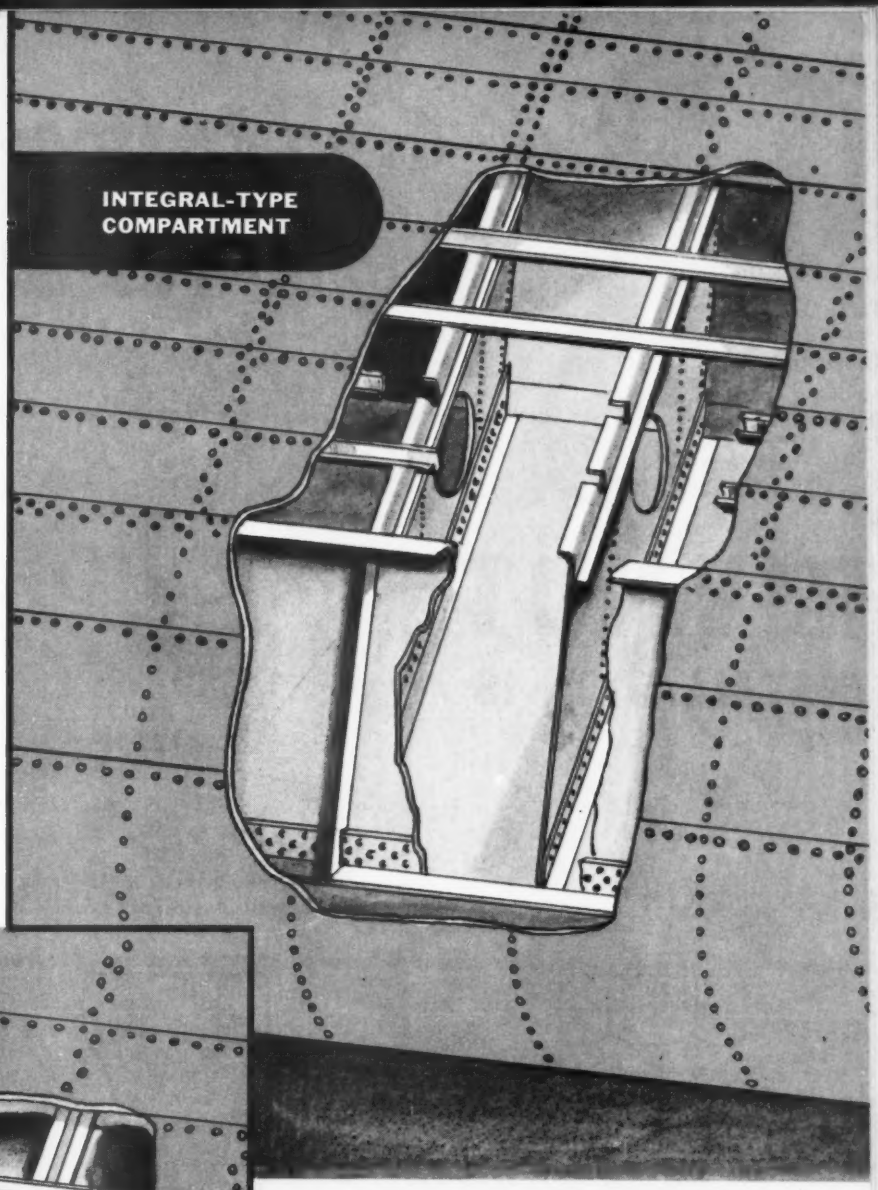
Since each airplane requires a custom-built product, engineers should write for complete information on each new installation. The B. F. Goodrich Company, Aeronautical Division, Akron, Ohio.

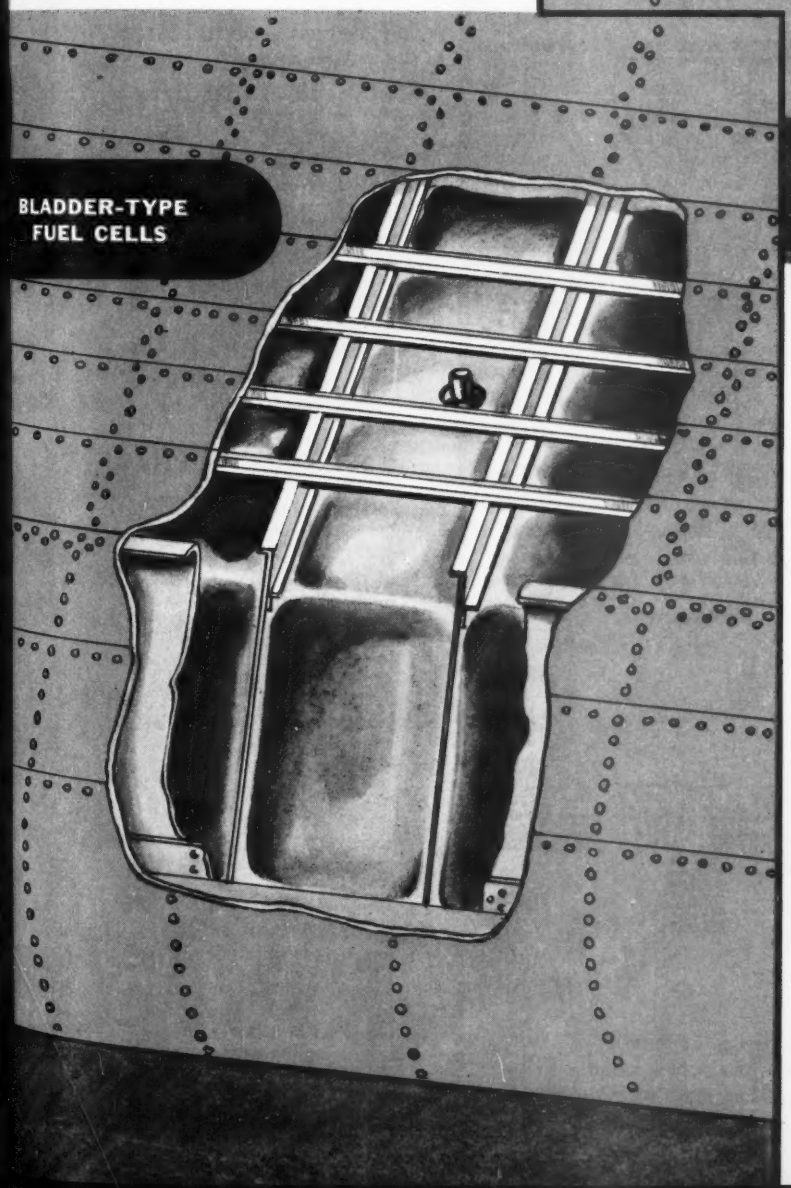
MAKERS OF B. F. GOODRICH TIRES AND OVER 80 RUBBER AND SYNTHETIC RUBBER PRODUCTS FOR AIRPLANES

ARMY E NAVY

THESE SKETCHES SHOW YOU WHY

BLADDER-TYPE FUEL CELLS ARE BETTER





WING SKIN is actually outside of tank in integral-type compartment (above). Rivets and seams are under constant strain, even in rigid wings, and may loosen and cause leakage. Minor crashes can split seams wide open. B. F. Goodrich "bladder-type" cell (left) fits between wing supports as individual unit. Being flexible, the cell walls give with any normal wing movement and resist the buckling effects of minor crashes.

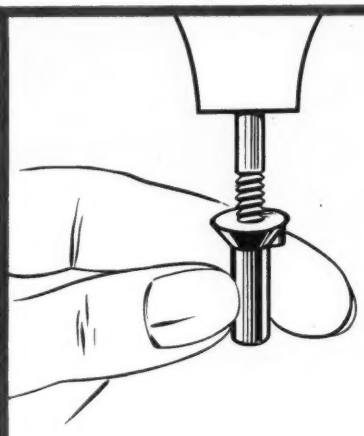
In war or peace

B.F.Goodrich

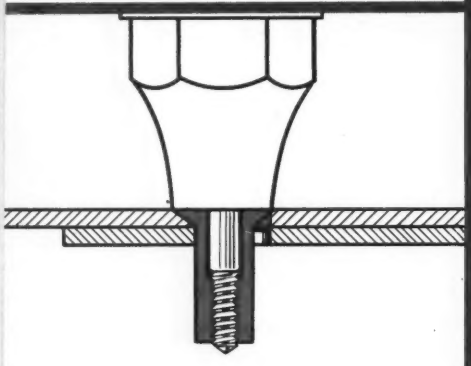
FIRST IN RUBBER

10 Good Reasons why you should Blind-Fasten with RIVNUTS

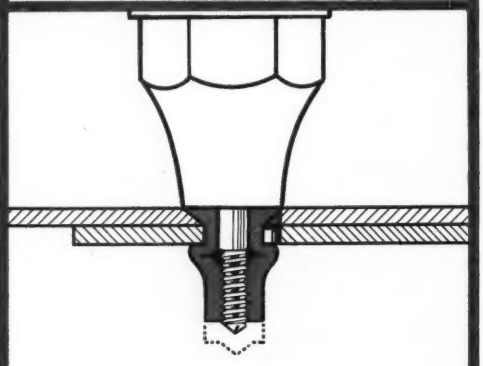
RIVNUT INSTALLATION IS SIMPLE FAST FOOLPROOF!



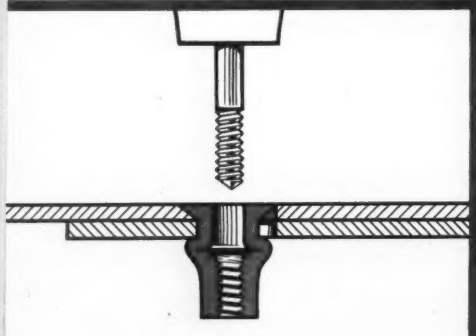
1 Thread Rivnut all the way on to pull-up stud of heading tool.



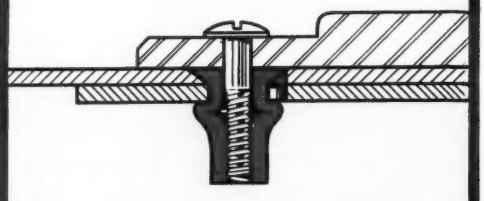
2 Push Rivnut and pull-up stud into hole with Rivnut head firmly against, and at right angles to, the work.



3 A squeeze on the tool lever retracts the pull-up stud slightly, causing a lateral bulge upset of the Rivnut.



4 Next, unscrew pull-up stud, leaving threaded core of Rivnut available for use as nut plate.



5 Attaching accessory is easy now—just screw it on. Rivnut threads grip screws firmly after upset.

Here's a combination of advantages no other blind fastener can match

- Dual use—can serve as blind rivet or nut plate or both
- Simple, one-piece construction
- Unusually wide bearing surface
- Requires very small hole
- Forms a compression fit
- Speed of installation
- Economical
- Can be used as received
- Wide range of types and sizes
- Available with key to increase torsion resistance

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B.F.Goodrich

RIVNUT

IT'S A RIVET...IT'S A NUT PLATE

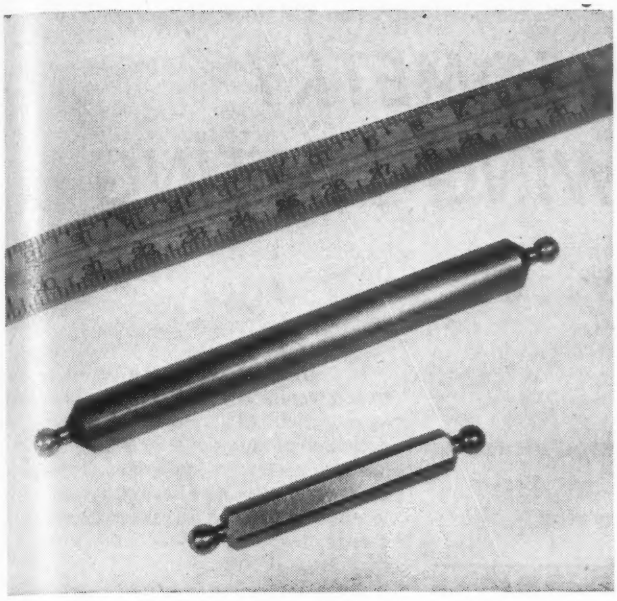


Fig. 3. Universal sine bar with ball ends to eliminate angle allowance. Flat on bar permits easy and accurate attachment. (Curtiss-Wright photo.)

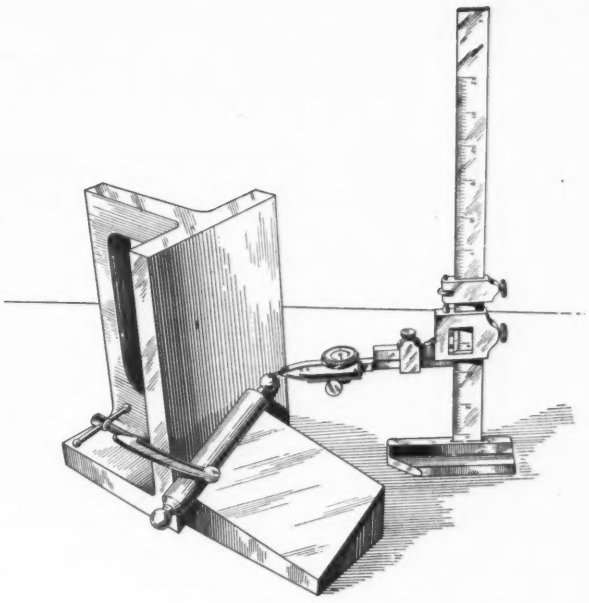


Fig. 4. This sketch depicts use of universal sine bar when measuring compound angle in conjunction with height gage and .001-in. indicator.

which would be the case with standard sine bars where thickness is taken into consideration. Since all points on the ball are equally distant from the center, the highest point is constant.

Two sizes are used with over-all lengths of 5.500 in. and 10.500 in., respectively. The larger size is applicable where large parts are involved but the smaller bar meets ordinary shop requirements. The balls are of .500 in. dia. The body diameters are $\frac{11}{16}$ in. and 1 in., respectively.

The balls are butt-welded to a shank, ground to fit center bore of rod. Each bar has two counterbored drill holes tapped for set screws holding the shank securely in position. Exact concentricity is maintained on assembly.

A lengthwise surface of the rods is flat-ground to prevent rolling and to enable clamping against a surface plate. The ends of the bar are chamfered approximately 45 deg. Bar is always used in conjunction with some true surface from which measurements can be taken (as shown in Fig. 4).

Use of jigs and compound angle plates is minimized in tooling for manufacturing aircraft parts by a device (Fig. 5) designed by Ray C. Albrecht, a foreman in the tool department, and further developed by Alvin W. Mueller of tool design and production planning group, who added a compound angle plate which can be used for milling, shaping, planing, or grinding.

Value of the instrument in time saving, tool saving, and setting of compound angles is considerable. On one experimental job on which the device was applied —a main spar fitting on a center panel —at least three jigs and two compound angles were eliminated.

Construction is simple. A cylindrical sine bar, $\frac{3}{4}$ by 6 in., pivots on a hinge pin in the upper left-hand corner of a bracket block, 2x6x$\frac{3}{8}$ in. A slot 45 deg. in length and on a $1\frac{1}{2}$-in. radius from the pivot, serves as a guide for a rocker arm bolt placed through the sine bar. This bolt has a flat elliptical head which fits snugly in the slot. A wing nut on the end of the bolt locks the bar in position. Bar has a lengthwise flat surface which bears against the block, and an upright pin on the end of the bar provides a pull knob. Holes are drilled in each upper corner of the block for attachment to the edge of the angle plate.

Incorporating the compound angle determinant just described, Alvin W. Mueller designed a compound angle plate that eliminates calculating in machining and

(*Turn to page* 263)

Fig. 5. Compound angle determinant composed of sine bar attached to base for determining foreshortened angles without use of mathematical calculations. Instrument may be attached to any combination of angle plates or other instruments. (Curtiss-Wright photo.)

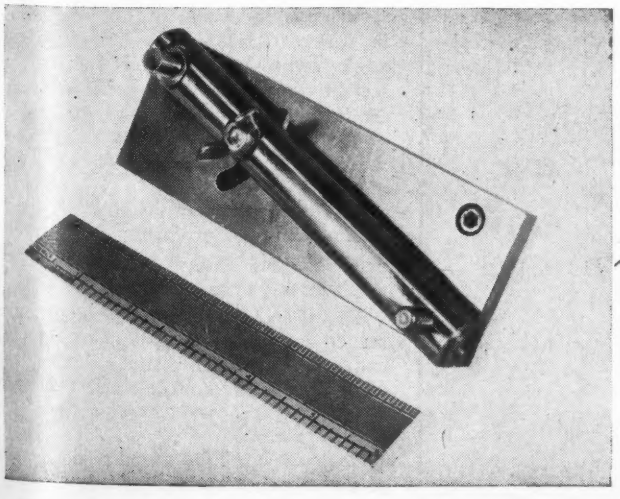
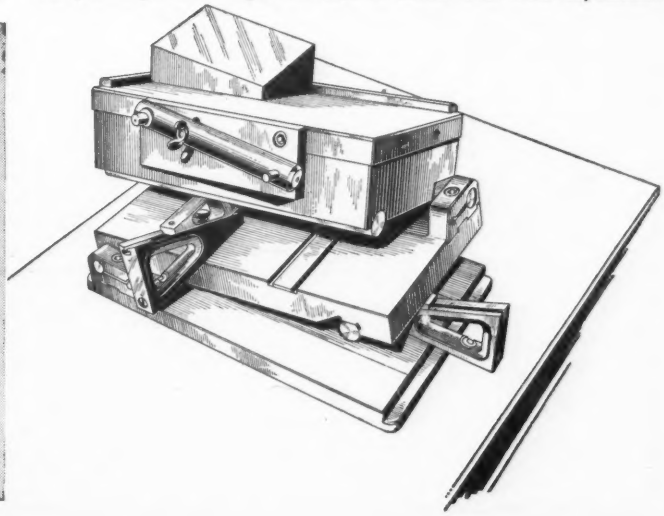


Fig. 6. This compound angle plate assembly, known as the Magnasine, incorporates compound angle determinant shown in Fig. 5. Sine bar is set to desired angle, then brought parallel to base. Adaptable planed wedges are used to obtain final close adjustment.



ANALYTIC GEOMETRY FOR SPEEDIER WING LOFTING

PART III

By R. W. FEENY, *Loft Engineer, Northrop Aircraft, Inc.*

Methods for obtaining many vital dimensions of canted structural wing members are described in this third part of our series on simplified wing development by use of analytic geometry.

IN OUR PREVIOUS ARTICLES we sidestepped the actual procedure involved in obtaining equations of canted structural members in the wing. These structures, which are canted in both plan view and front view, are often called skewed. Because of the numerous problems which occur in the airplane involving this type of assembly, we should know the methods used which can most easily give us the desired answers.

If the equations of these canted structures can be found, then by the use of them in conjunction with our other equations of structural parts, many vital dimensions may be obtained.

Before we can delve further into the use of analytic geometry, we must first understand some of the principles and theories used for determining the equations of canted planes.

The equation of a canted plane can be defined as an equation, in terms of *X*, *Y*, and *Z*, which is satisfied by the coordinates of every point upon that plane and by the coordinates of no other point. The only information required is the direction of slope of the plane and its location.

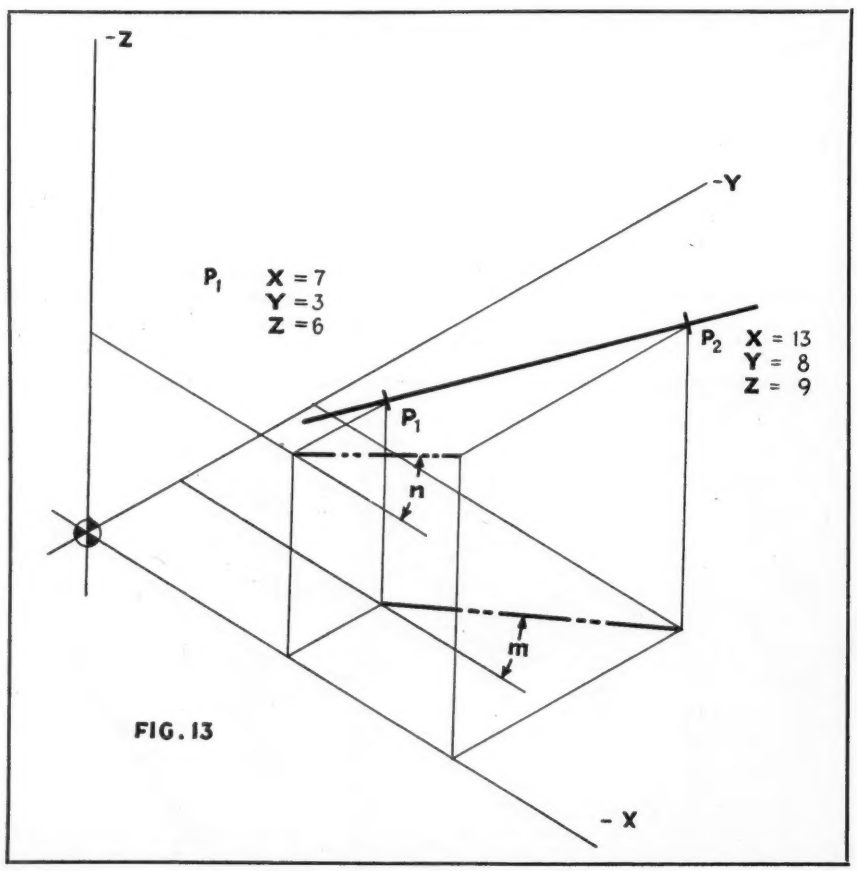


FIG. 13

If a group of planes are set up normal to a given line in space, the planes will be parallel. Therefore, so far as the direction of the slope is concerned, it is only necessary to know the direction of the normal to the desired plane. For location, it is only necessary to know the coordinates of any one point which lies within the desired plane.

Direction of Normal By Use of Direction Ratios

In dealing with lines in space, it is necessary to fix the direction taken by the line in the simplest manner possible. We do this by establishing what is called the direction ratios of the line. These are sometimes called direction numbers or direction components.

Direction ratios can be described as the ratio of the line's change in direction with respect to its "X", "Y", and "Z" axes, These can be found by the change in coordinates between any two points on the line.

$$\text{Dir. ratios} = (X_2 - X_1) : (Y_2 - Y_1) : (Z_2 - Z_1)$$

Example 1 (Fig. 13): Determine the direction ratios of a line passing between points P_1 (7, 3, 6) and P_2 (13, 8, 9).

$$\text{Dir. ratios} = (13 - 7) : (8 - 3) : (9 - 6) = 6 : 5 : 3$$

For convenience, the direction ratios are usually reduced so that the largest is equal to unity (1). This then makes the other two values equal to the tangents of the angles formed by the projection of the lines on the coordinate axis planes.

Direction ratios of the foregoing example would then be—

$$\frac{6}{6} : \frac{5}{6} : \frac{3}{6} \text{ Or } 1 : 0.83333 : 0.50000$$

in which 0.83333 is the tangent of the angle formed by the X axis and the projection of the line on the "X Y plane." At the same time 0.50000 is the tangent of the angle formed by the "X" axes and the projection of the line on the "X Z plane."

These direction ratios are sometimes designated in other forms, however, the most popular being the following two—

$$1 : m : n \quad \text{or} \quad A : B : C$$

The *m* and *n* values are familiar to the reader as the slopes of the line in plan and front view. To distinguish the slope of a normal to a plane from that of a structural line, we therefore use the *A:B:C* form.

Example 2: Find the direction ratios of the aileron hinge line having a sweep-

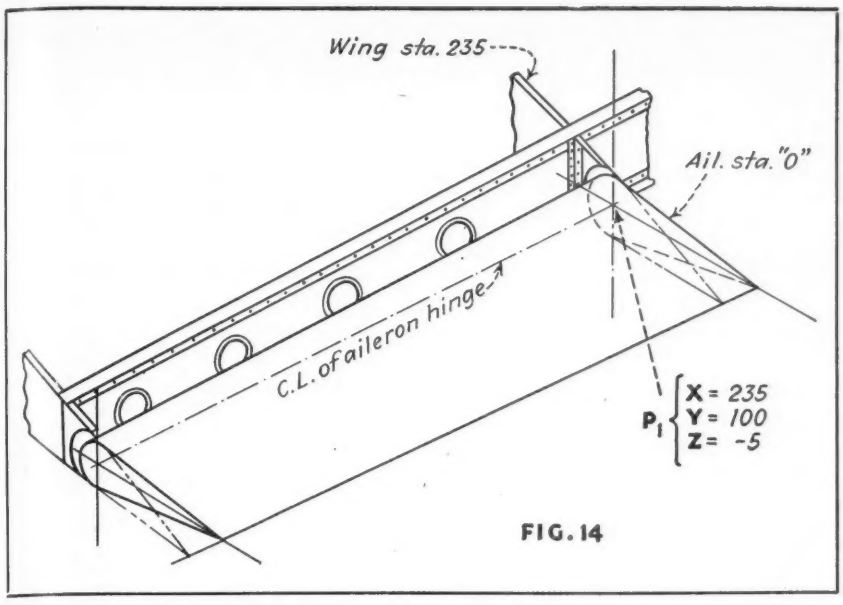


FIG. 14

back of 12° and a rise in front view of 2° 30′.

Dir. ratios = 1 : m : n or 1 : Tan 12° : Tan 2° 30′
= 1 : 0.21256 : 0.04366

Equations of Canted Planes In the Wing

Any plane in space can be represented analytically by the general equation—

$$Ax + By + Cz + D = 0$$

Given the coordinates of any point lying within the desired plane, the value of D is known to be—

$$D = -(Ax_1 + By_1 + Cz_1)$$

By substituting into the original equation and by transferring quantities, the following general form for the equation of any plane in space may be found:

$$A(x - x_1) + B(y - y_1) + C(z - z_1) = 0$$

The general equation, as shown above, always represents a plane in which the coefficients A, B, and C are the direction ratios of the normal to the plane, while the x_1, y_1 and z_1 are the coordinates of any point lying on the plane.

Example 3: Given a plane passing through point P_1 (4, 6, 9) and having for the direction ratios of its normal 1:0.250:0.120, find through use of the general formula, the equation of the canted plane.

$$A(x - x_1) + B(y - y_1) + C(z - z_1) = 0$$
$$1(x-4) + 0.25(y-6) + 0.12(z-9) = 0$$
$$X + 0.250\,Y + 0.120\,Z - 6.580 = 0$$

Example 4 (Fig. 14): Given the aileron previously mentioned, determine the equation of its inboard station constructed normal to the hinge line. The station passes through the hinge at a point on wing station 235 having coordinates of (235, 100, —5). The direction ratios of the normal, which is the hinge line, are 1:0.21256:0.04366.

$$A(x - x_1) + B(y - y_1) + C(z - z_1) = 0$$
$$1(x - 235) + 0.21256(y - 100) + 0.04366(z + 5) = 0$$
$$X + 0.21256\,Y + 0.04366\,Z - 256.038 = 0$$

Example 5 (Fig. 15): Determine the equation of a plane normal to the leading edge of the wing. This plane intersects the front spar at the wing reference trace and wing station 44, the coordinates of the point being (44, 41.5, 0) and the direction ratios of the L.E. being 1:0.240:0.080.

$$A(x - x_1) + B(y - y_1) + C(z - z_1) = 0$$
$$1(x - 44) + 0.240(y - 41.5) + 0.080(z - 0) = 0$$
$$X + 0.240\,Y + 0.080\,Z - 53.960 = 0$$

The above examples show that the equation of a canted plane can be found by using the coordinates of any point within the desired plane. It is not necessary to use the intersection of the hinge line with the plane at that point, though this is usually the most conveniently located point. It is, however, very important that the coordinates of the point be determined correctly and that all three values X, Y, and Z be used.

Many cases occur in the airplane when the equation of a canted plane is desired. However, quite often the plane is determined by some other factors than the direction of its normal. Many times the direction of the normal is not immediately available. A plane may be determined, for example, if two lines lying within the plane are given, or if the coordinates of three non-collinear points on the plane are known. Space does not permit us to demonstrate the methods used in this type of a problem. However, the author will be glad to answer any inquiries regarding these or any other feature of this series.

True Angles Between Lines or Planes

Having found one of the uses for the direction ratios of a line, we now advance to other important uses for them—that is, in determining the true angle between any two lines in space. Once again we revert to a general formula for this information:

$$\text{Cos}\,\theta = \frac{A\,A_1 + B\,B_1 + C\,C_1}{\sqrt{A^2 + B^2 + C^2}\,\sqrt{A_1^2 + B_1^2 + C_1^2}}$$

The above equation is used when the angle between two lines L and L_1 is desired, the direction ratios of the two lines being respectively $A:B:C$ and $A_1:B_1:C_1$.

Example 6: Given two lines in space, whose directions are known, determine the true angle between the lines.

Direction ratios of L; 0.4 : 0.5 : 1
Direction ratios of L_1; 1 : 0.2 : 0.3

$$\text{Cos}\,\theta = \frac{0.4\,(1) + 0.5\,(0.2) + 1\,(0.3)}{\sqrt{(0.4)^2 + (0.5)^2 + 1}\,\sqrt{1 + (0.2)^2 + (0.3)^2}} = 0.634$$

Angle θ therefore is 50° 39′

Example 7 (Fig. 16): Given a control cable passing between three pulleys P_1, P_2, and P_3, design requirements make it necessary to determine the true angle formed by the cable as it passes over the middle pulley P_2. The location of the pulleys are given as follows:

P_1 (12, 40, 4) P_2 (20, 52, 6) P_3 (23, 60, 5)

Direction ratios between pulleys P_1P_2
8 : 12 : 2

Direction ratios between pulleys P_2P_3
−3 : −8 : 1

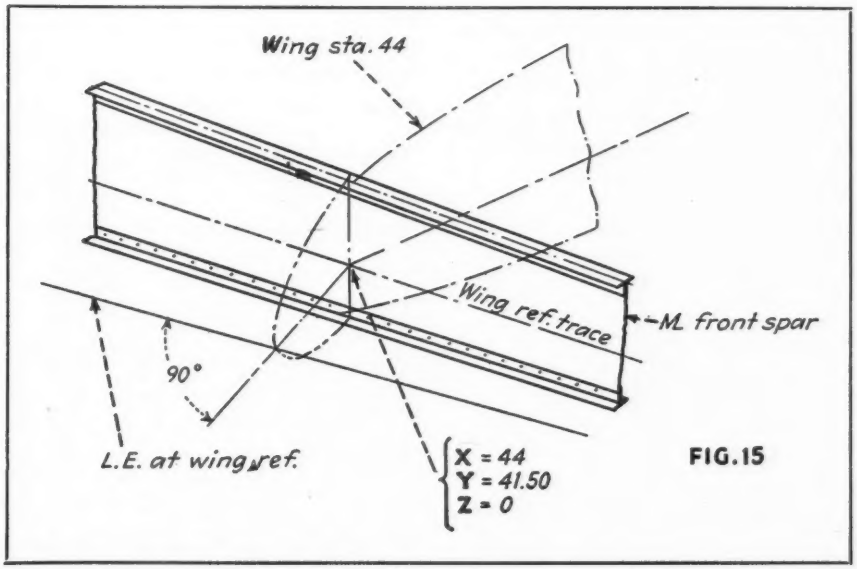
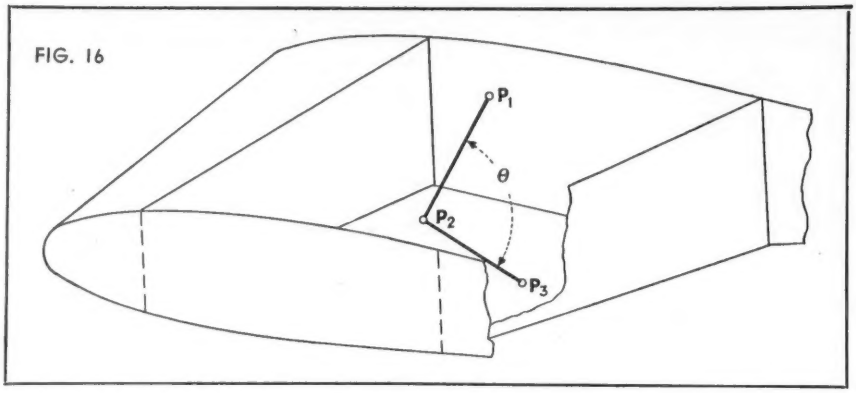


FIG. 15

FIG. 16



$$\text{Cos } \theta = \frac{8(-3) + 12(-8) + 2(1)}{\sqrt{8^2+12^2+2^2}\,\sqrt{(-3)^2+(-8)^2+1}} = -0.965$$

Therefore angle θ is 164° 48′

Whenever two lines intersect, there are always two different angles formed, an acute angle and the supplement. Therefore, it is important to realize that the formula obtains the angle between the positive directions of the two lines. The positive direction being the largest of the three direction ratios having a positive sign.

Example 8: When—

0.4 : 0.5 : 1 the positive direction is up.
8 : 12 : 2 the positive direction is aft.

Generally the angle can be determined approximately by observation, in order to make sure that the correct angle is being obtained.

True Angles Between Planes

Many examples occur in the airplane when the true angle between two intersecting structural planes is desired. This may happen in the case of (a) an attaching fitting between a canted wing station and a spar, (b) the attachment of two canted windshields, or (c) the attachment of a pulley bracket to a canted bulkhead.

In order to determine the structure required to correctly make these attachments, the true angle must be quickly and accurately obtained. Once again the use of analytic geometry will do the job quickly and with results far beyond the accuracy obtainable by present methods of descriptive geometry or by engineering layouts.

The true angle between two intersecting planes is always measured in a theoretical plane lying normal to the line of intersection. The true angle, therefore, can be proved to be equal to the angle formed by the intersection of two lines each normal to one of the planes (see Fig. 17).

Therefore, it is only necessary to have the direction ratios of the normal to the planes in order to solve for the true angle. These are found of course in the equation of the planes.

Example 9: A canted wing station intersects a skewed spar. In order to design an attaching forging it is necessary to know the true angle between the two planes. It is assumed of course that the equations of both canted structures are already known.

Equation of cant station.

$$X = 0.32\,Y + 0.15\,Z - 82 = 0$$

Equation of skewed spar.

$$0.2\,X + Y - 0.05\,Z - 100 = 0$$

$$\text{Cos } \theta = \frac{AA_1 + BB_1 + CC_1}{\sqrt{A^2+B^2+C^2}\,\sqrt{A_1^2+B_1^2+C_1^2}}$$

$$\text{Cos } \theta = \frac{1(0.2) + 0.32(1) + 0.15(-0.05)}{\sqrt{1+(0.32)^2+(0.15)^2}\,\sqrt{(0.2)^2+1+(-0.05)^2}} = 0.47327$$

The true angle of intersection is therefore 61° 45′

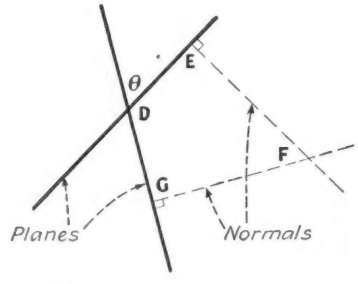
Example 10: The outboard flap structural station is required to be parallel to the inboard station of the aileron in order to maintain a constant clearance for the movement of the aileron. Determine the true amount of cant which must be given to the regular flap station in order to conform to these requirements.

Equation of the flap station

$$X + 0.215\,Y - 0.099\,Z - 240 = 0$$

Equation of the aileron station

$$X + 0.052\,Y + 0.020\,Z - 225.83 = 0$$



The sum of the interior angles D, E, F, and G is equal to 360°
Angles G and E are each 90°
Angle F = 180° - Angle D
Angle θ = 180° - Angle D
Angle F = Angle θ

FIG. 17

$$\text{Cos } \theta = \frac{1(1) + 0.215(0.052) - 0.099(0.020)}{\sqrt{1+0.215^2+(-.099)^2}\,\sqrt{1+(0.052)^2+(0.020)^2}} = 0.98055$$

Angle θ = 11° 19′

The flap station must therefore be rotated 11° 19′ (true) in order to make it parallel to the aileron station.

Intersections of Lines and Planes

One of the benefits of the analytic geometry method of calculating the equations of lines and planes is the ability to determine their intersections. It makes no difference whether the plane is a simple wing station normal to the reference plane or a double canted bulkhead. The location of the point of intersection can be easily obtained.

Anyone familiar with the old method of finding the intersections of lines and planes realizes that it requires an involved layout and an excellent knowledge of descriptive geometry. When large layouts are required the accuracy obtainable is quite often inadequate and may be the cause for failure of structural parts to coordinate properly. By means of analytic geometry it is a simple matter to obtain the location of the point of intersection within 0.0001 in.

Intersections Involving Double Canted Stations

In solving the intersection points on a double canted station, it is necessary to use both the "Y" and "Z" equations of the line simultaneously. This is due to the fact that the surface of a double canted plane travels in three directions at once. This therefore requires that at least two of the unknowns be given in terms of the third in order to reach a solution.

Example 11: Determine the coordinates for the point of intersection between the rear spar upper ML and the canted wing station, when the equations of both are known.

Equations of spar ML: $Y = 0.075\,X + 95$
$Z = -0.050\,X + 16$
Equation of canted station: $X + 0.24\,Y - 0.06\,Z - 56.240 = 0$

Using the equations of the spar ML we may substitute the values of "Y" and "Z" into the equation of the canted wing station, thus leaving just one unknown which may be easily determined.

$$X + 0.24(0.075\,X + 95) - 0.06(-0.05\,X + 16) - 56.240 = 0$$
$$X + 0.018\,X + 22.8 + 0.003\,X - 0.96 - 56.240 = 0$$
$$1.021\,X = 34.400$$
$$X = 33.692$$

Now by substituting this value into the original equations of the spar ML the "Y" and "Z" coordinates may be obtained.

$$Y = 0.075(33.692) + 95 = 2.527 + 95 = 97.527$$
$$Z = -0.050(33.692) + 16 = -1.685 + 16 = 14.315$$

Example 12: Find the intersection point where a control cable passes through a

(*Turn to page 269*)

EQUIVALENT CHARTS For Aircraft Plumbing Fittings

They Speed Standardization at American Airlines

AT THE PRESENT TIME, there are three distinct types of fittings used in Army and commercial aircraft operated in the United States. They are the *AC*810 (*Parker Standard* type), the *AC*811 (*Parker Triple* type), and the *AN* type (see Fig. 1).

Purely in the interests of further standardization, many operating airlines are adopting one of these types throughout in their equipment. This constitutes quite a problem, since there are numerous connectors, elbows, tees, and crosses used in varying sizes and quantities in the various plumbing systems.

In an attempt to simplify the changeover program in American Airlines, a series of charts has been prepared (presented on the following pages). The charts outline *AN* fittings equivalent for *AC*810 and *AC*811 tube fittings, as well as *AN* pipe and hose fittings for existing *AC* and *Parker* types.

When replacing an *AC* tube fitting with an *AN* type, the mating fitting and all component parts (such as sleeves or connecting nuts) must also be replaced. This necessitates cutting the flares off existing lines, replacing existing fittings with *AN* type, and replacing lines. This may not be possible in all cases, since the existing lines may not be long enough for reflaring, in which case the lines would also be replaced.

Interchangeability

In most cases it is possible to substitute complete *AN* fittings (fittings, nuts, and sleeves) for *AC*811 or *NAF*. Exceptions will arise when straight threaded bosses are used, also in close installations where *AN* fittings will be too large. It is possible to interchange certain *AC* and *AN* components, as noted below. However, it is not good practice and should be avoided wherever possible.

Sleeves: The *AN*819 and *AC*811 "T" may be used interchangeably in all cases.

Nut and fitting bodies: Although the parts may appear to be the same, the threads on *AN* and *AC*811 type fittings are different in the $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, and $1\frac{1}{2}$-in. sizes; therefore in these sizes the threaded fitting parts (nuts and fitting bodies) cannot be interchanged. In the other sizes ($\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$, $\frac{5}{16}$, $1\frac{3}{4}$, and 2-in.) the threads are the same and thus *AC*811 "BT" nuts may be used with *AN* bodies. But even though the threads are the same, the *AN* nuts cannot be used on *AC*811 fitting bodies because the *AN* nut is longer and will bottom on the fitting shoulder before a tight seal is effected.

Tube flares: Because there is little difference between *AC* and *AN* flare angles, *AC*811 and *AN* tube flares or aluminum tube can be used interchangeably except in size #6. It is not recommended that *AN* and *AC*811 tube flares be used interchangeably on steel tubing.

Materials and Identification

Tube fittings: *AN* tube fitting bodies and nuts are available in steel and aluminum alloy. *AN*819 sleeves are available in Duronze III, cadmium or zinc plated, in addition to steel and aluminum alloy. Steel *AN* fittings may be identified by their black color and by the symbol "AN" stamped in the fitting (the manufacturer's trademark is also stamped in the fitting). Aluminum alloy fittings also bear the symbol "*AN*" as well as the trademark of the manufacturer and may be identified by their blue finish. Mating of steel with aluminum alloy fittings components is not recommended. In sizes $\frac{1}{2}$ and larger, *AN* Duronze III sleeves may be used with either steel or aluminum fittings. In sizes smaller than $\frac{1}{2}$ they can only be used with aluminum fittings. Duronze III sleeve may be identified by either a natural cadmium color or an olive drab color if zinc plated.

Hose and pipe fittings: *AN* type hose and pipe fittings are available in aluminum alloy and bronze. The same symbols present on *AN* tube fittings appear on hose and pipe fittings as well. The aluminum alloy fittings are blue. Bronze fittings are not plated or finished and may be identified by their natural bronze color.

Abbreviations: Designations "M.P.T." and "F.P.T." used on the following charts indicate male pipe thread and female pipe thread.

INDEX TO CHARTS

Tube Fittings . P. 166 to 177 **Hose Fittings . P. 178 to 180** **Pipe Fittings . P. 181 to 184**

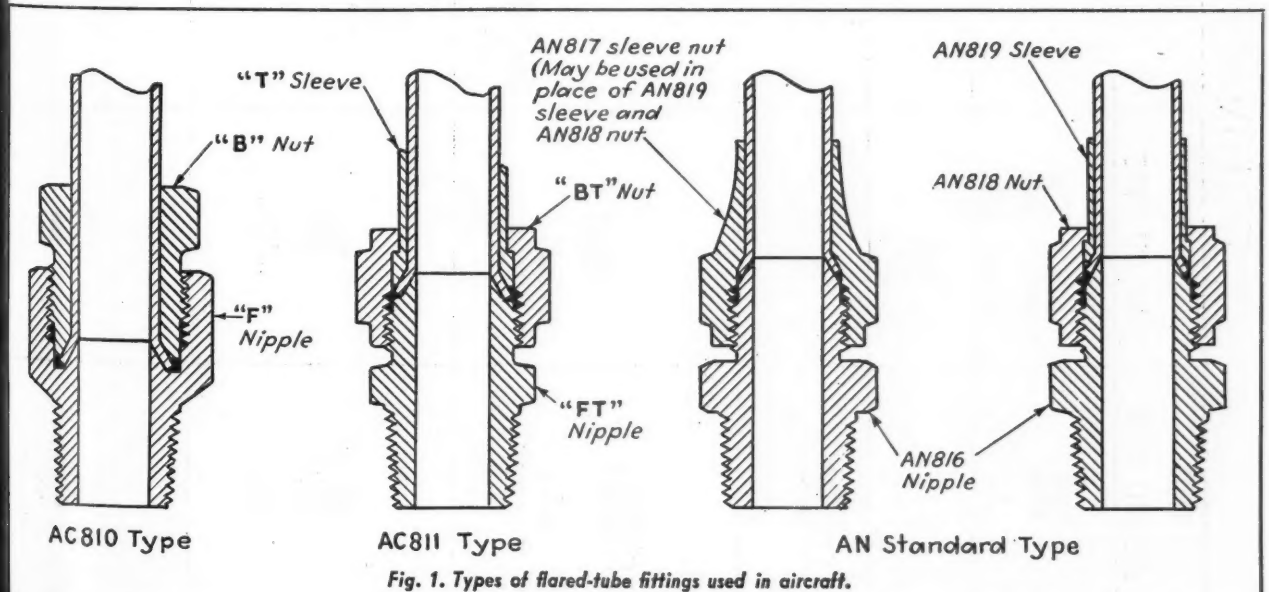
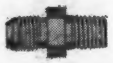
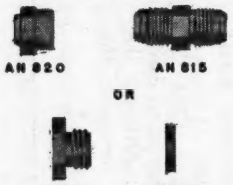
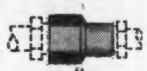
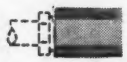


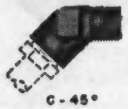
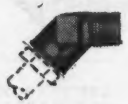
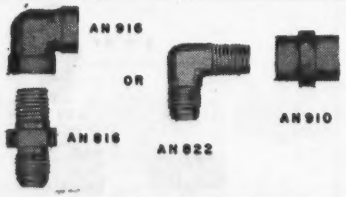
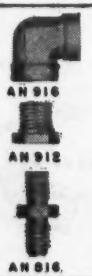
Fig. 1. Types of flared-tube fittings used in aircraft.

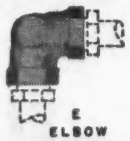
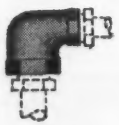
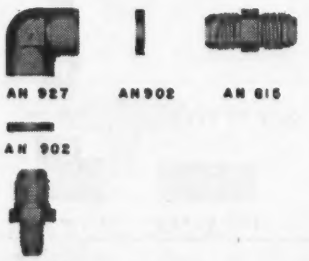
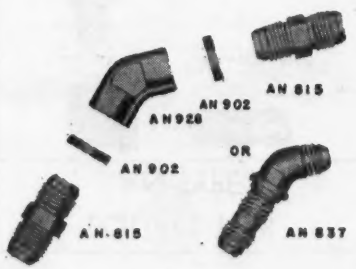
EQUIVALENTS CHART FOR TUBE FITTINGS

THIS AC 810 TYPE	OR THIS AC 811 TYPE	EQUALS THIS AN TYPE
B NUT	T SLEEVE — BT NUT	AN 819 — AN 818
	T SLEEVE	AN 819
F NIPPLE	FT NIPPLE	 AN 816
F NIPPLE (COMB. SIZE)	FT NIPPLE (COMB. SIZE)	IF M.P.T. IS LARGER USE AN 816 — AN 812 IF M.P.T. IS SMALLER USE AN 816 — AN 810 — AN 812 — AN 811
F N CAP	FNT PLUG NUT	 AN 820 — AN 815 OR AN 814 — AN 902
F N PLUG NUT	FNT CAP	AN 820

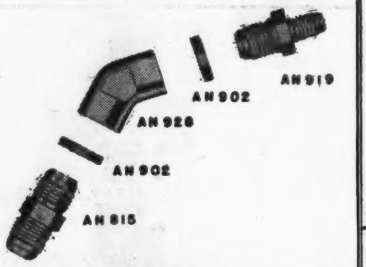
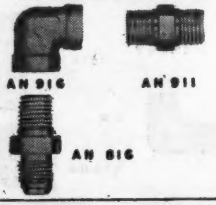
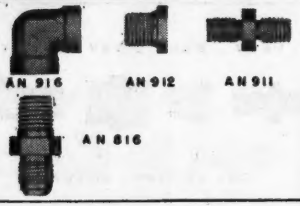
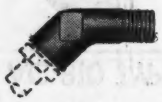
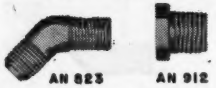
THIS AC 810 TYPE	OR THIS AC 811 TYPE	EQUALS THIS AN TYPE
H UNION	HT UNION	AN 815
 H UNION (COMB. SIZE)	HT UNION (COMB. SIZE)	AN 919
 G CONNECTOR	GT CONNECTOR	AN 816 — AN 910
G CONNECTOR (COMB. SIZE)	GT CONNECTOR (COMB. SIZE)	IF P.P.T. IS LARGER USE AN 816 — AN 812 — AN 910 IF P.P.T. IS SMALLER USE AN 816 — AN 910 — AN 812
C ELBOW	ELBOWS CT ELBOW	AN 822
C ELBOW (COMB. SIZE)	CT ELBOW (COMB. SIZE)	IF M.P.T. IS LARGER USE AN 822 — AN 812 IF M.P.T. IS SMALLER USE AN 822 — AN 810 — AN 812 — AN 811

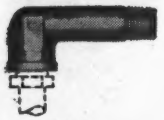
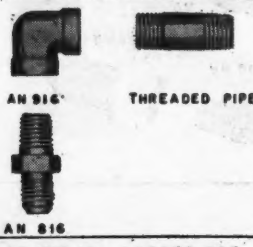
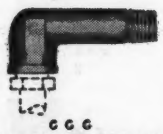
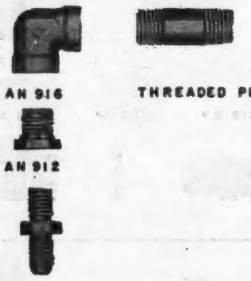
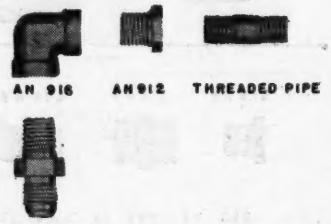
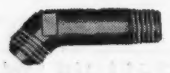
EQUIVALENTS CHART FOR TUBE FITTINGS

THIS AC 810 TYPE	OR THIS AC 811 TYPE	EQUALS THIS AN TYPE
 C - 45° ELBOW	CT - 45° ELBOW	AN 823
 C - 45° ELBOW (COMB. SIZE)	CT - 45° ELBOW (COMB. SIZE)	IF M.P.T. IS LARGER USE AN 823 AN 912 IF M.P.T. IS SMALLER USE AN 823 AN 910 AN 912 AN 911
D ELBOW	DT ELBOW	 AN 916 OR AN 916 AN 822 AN 910
D ELBOW (COMB. SIZE)	DT ELBOW (COMB. SIZE)	 AN 916 AN 912 AN 816
D - 45° ELBOW	DT - 45° ELBOW	AN 823 AN 910

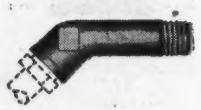
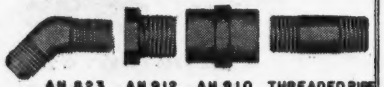
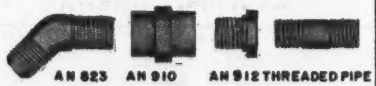
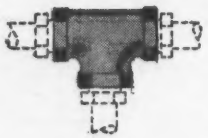
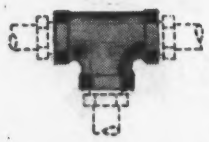
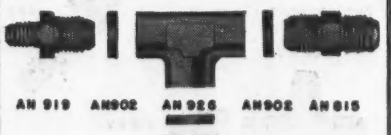
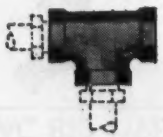
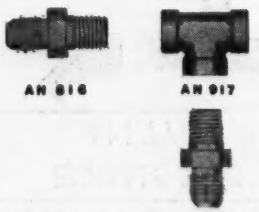
THIS AC 810 TYPE	OR THIS AC 811 TYPE	EQUALS THIS AN TYPE
D - 45° ELBOW (COMB. SIZE)	DT - 45° ELBOW (COMB SIZE)	IF F.P.T. IS LARGER USE AN 823 AN 912 AN 910 IF F.P.T. IS SMALLER USE AN 823 AN 910 AN 912
 E ELBOW	ET ELBOW	AN 833 OR AN 821
 E ELBOW (COMB. SIZE)	ET ELBOW (COMB. SIZE)	 AN 927 AN 902 AN 815 AN 902 AN 919
E - 45° ELBOW	ET - 45° ELBOW	 AN 815 AN 902 AN 928 AN 902 OR AN 815 AN 837

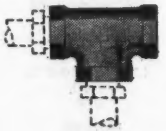
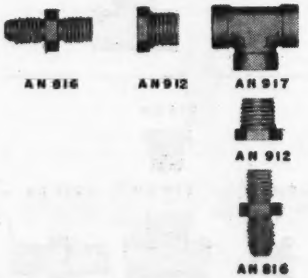
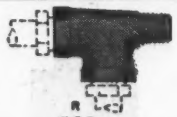
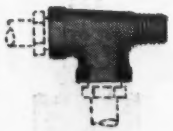
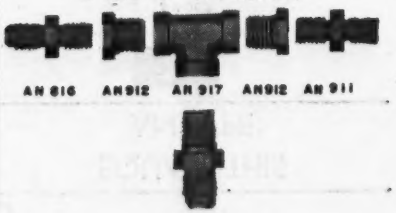
EQUIVALENTS CHART FOR TUBE FITTINGS

THIS AC 810 TYPE	OR THIS AC 811 TYPE	EQUALS THIS AN TYPE
E-45° ELBOW (COMB. SIZE)	ET-45° ELBOW (COMB. SIZE)	 AN 919 AN 902 AN 926 AN 902 AN 815
CC ELBOW-LONG	CCT ELBOW-LONG	 AN 916 AN 911 AN 816
CC ELBOW-LONG (COMB. SIZE)	CCT ELBOW-LONG (COMB. SIZE)	 AN 916 AN 912 AN 911 AN 816
CC-45° ELBOW-LONG	CCT-45° ELBOW-LONG	AN 823 AN 910 AN 911
 CC-45° ELBOW-LONG (COMB. SIZE)	CCT-45° ELBOW-LONG (COMB. SIZE)	IF M.P.T. IS LARGER USE  AN 823 AN 912 IF M.P.T. IS SMALLER USE AN 823 AN 910 AN 912 AN 911

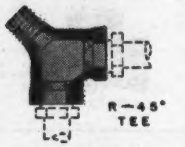
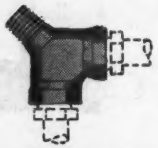
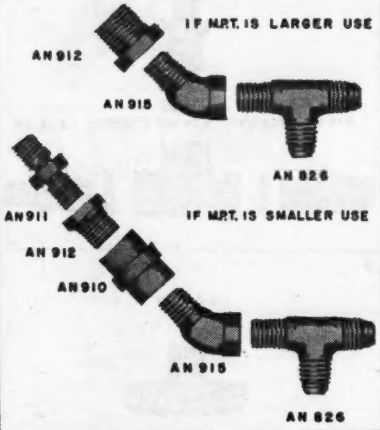
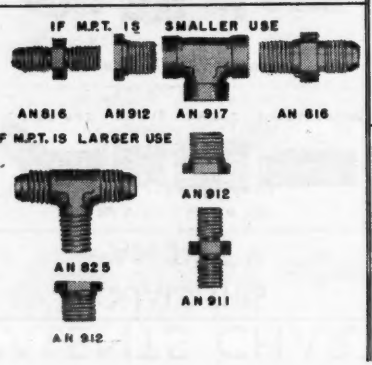
THIS AC 810 TYPE	OR THIS AC 811 TYPE	EQUALS THIS AN TYPE
 CCC ELBOW - EXTRA LONG	CCCT ELBOW - EXTRA LONG	 AN 916 THREADED PIPE AN 816
 CCC ELBOW - EXTRA LONG (COMB. SIZE)	CCCT ELBOW - EXTRA LONG (COMB. SIZE)	IF M.P.T. IS LARGER USE  AN 916 THREADED PIPE AN 912 AN 816 IF M.P.T. IS SMALLER USE  AN 916 AN 912 THREADED PIPE AN 816
CCC-45° ELBOW - EXTRA LONG	 CCCT-45° ELBOW - EXTRA LONG	AN 823 AN 910 THREADED PIPE

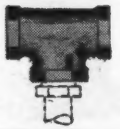
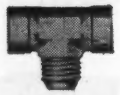
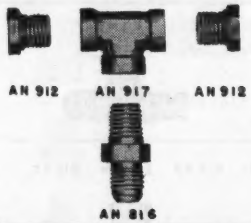
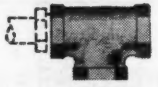
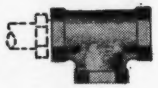
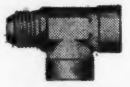
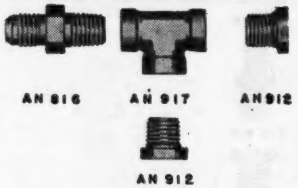
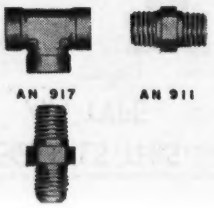
EQUIVALENTS CHART FOR TUBE FITTINGS

THIS AC 810 TYPE	OR THIS AC 811 TYPE	EQUALS THIS AN TYPE
 CGC-45° ELBOW-EXTRA LONG (COMB. SIZE)	CGCT-45° ELBOW-EXTRA LONG (COMB. SIZE)	IF M.P.T. IS LARGER USE  AN 823 AN 912 AN 910 THREADED PIPE IF M.P.T. IS SMALLER USE  AN 823 AN 910 AN 912 THREADED PIPE
TEES		
 J TEE	J T TEE	AN 824
 J TEE (COMB. SIZE)	J T TEE (COMB. SIZE)	 AN 919 AN902 AN 926 AN902 AN 815 AN 902 AN 919
 M TEE	M T TEE	 AN 816 AN 917 AN 816

THIS AC 810 TYPE	OR THIS AC 811 TYPE	EQUALS THIS AN TYPE
 M TEE (COMB. SIZE)	M T TEE (COMB. SIZE)	 AN 816 AN 912 AN 917 AN 912 AN 816
O TEE	O T TEE	AN 816 AN 917 AN 816
O TEE (COMB. SIZE)	O T TEE (COMB. SIZE)	AN 816 AN 912 AN 917 AN 912 AN 816
 R TEE	R T TEE	AN 926
 R TEE (COMB. SIZE)	R T TEE (COMB. SIZE)	IF M.P.T. IS LARGER USE AN 926 AN 912 IF M.P.T. IS SMALLER USE  AN 816 AN 912 AN 917 AN 912 AN 911 AN 816

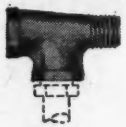
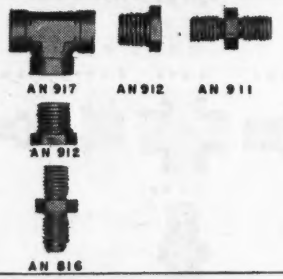
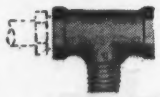
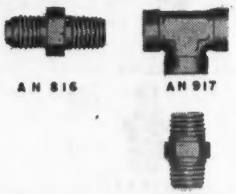
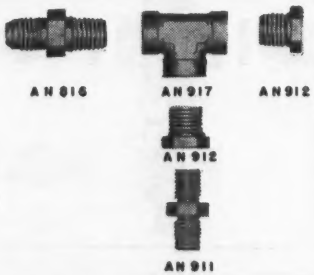
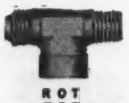
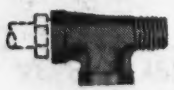
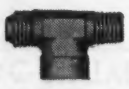
EQUIVALENTS CHART FOR TUBE FITTINGS

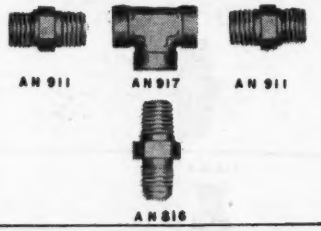
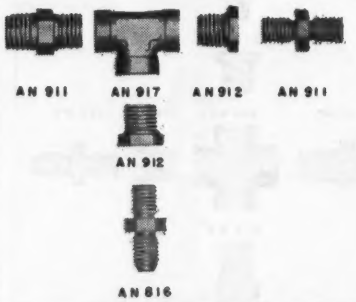
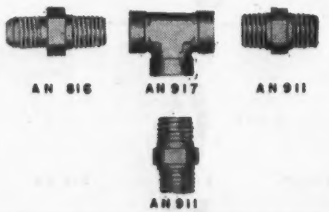
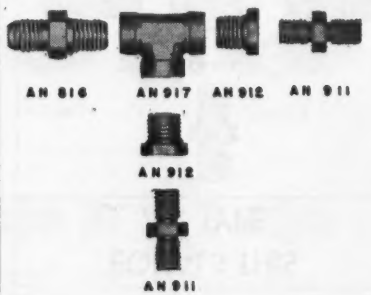
THIS AC 810 TYPE	OR THIS AC 811 TYPE	EQUALS THIS AN TYPE
 R-45° TEE	RT-45° TEE	AN 915 AN 826
 R-45° TEE (COMB. SIZE)	RT-45° TEE (COMB. SIZE)	 IF M.P.T. IS LARGER USE AN 912 AN 915 AN 826 AN 911 IF M.P.T. IS SMALLER USE AN 912 AN 910 AN 915 AN 826
S TEE	ST TEE	AN 825
S TEE (COMB. SIZE)	ST TEE (COMB. SIZE)	 IF M.P.T. IS SMALLER USE AN 816 AN 912 AN 917 AN 816 IF M.P.T. IS LARGER USE AN 912 AN 825 AN 911 AN 912

THIS AC 810 TYPE	OR THIS AC 811 TYPE	EQUALS THIS AN TYPE
MM TEE	MMT TEE	AN 917 AN 816
 MM TEE (COMB. SIZE)	 MMT TEE (COMB. SIZE)	 AN 912 AN 917 AN 912 AN 816
 MO TEE	MOT TEE	AN 816 AN 917
 MO TEE (COMB. SIZE)	 MOT TEE (COMB. SIZE)	 AN 816 AN 917 AN 912 AN 912
MR TEE	MRT TEE	 AN 917 AN 911 AN 816

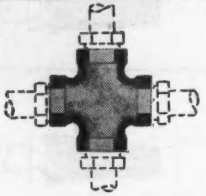
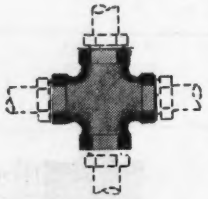
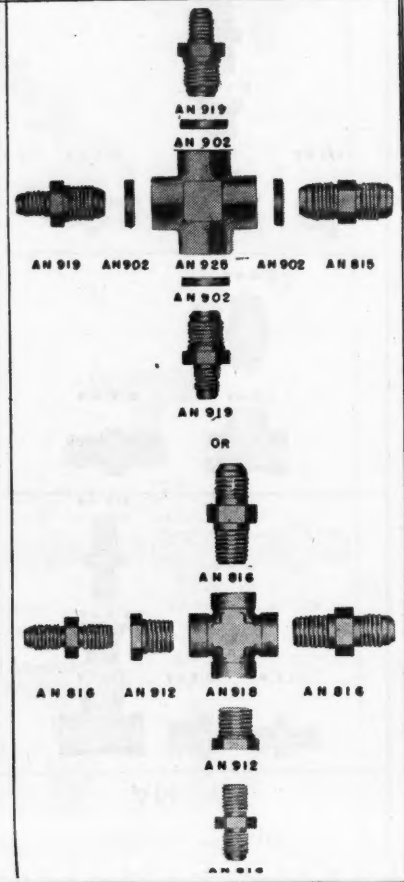
EQUIVALENTS CHART FOR TUBE FITTINGS

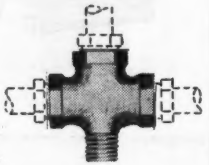
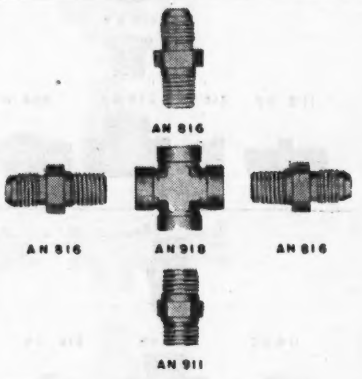
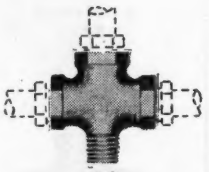
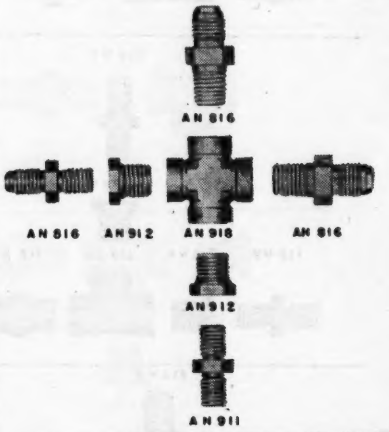
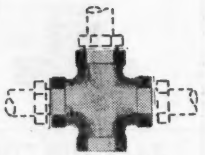
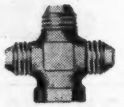
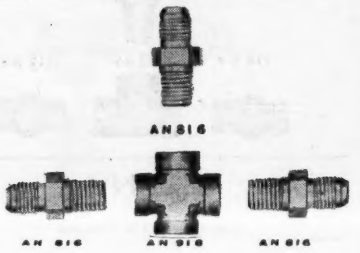
EQUIVALENTS CHART FOR TUBE FITTINGS

THIS AC 810 TYPE	OR THIS AC 811 TYPE	EQUALS THIS AN TYPE
 MR TEE (COMB. SIZE)	MRT TEE (COMB. SIZE)	 AN 917 AN 912 AN 911 AN 912 AN 816
 MS TEE	MST TEE	 AN 816 AN 917 AN 911
MS TEE (COMB. SIZE)	MST TEE (COMB. SIZE)	 AN 816 AN 917 AN 912 AN 912 AN 911
RO TEE	 ROT TEE	AN 816 AN 917 AN 911
 RO TEE (COMB. SIZE)	 ROT TEE (COMB. SIZE)	AN 816 AN 912 AN 917 AN 911 AN 912

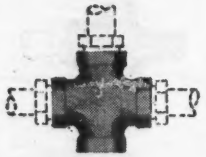
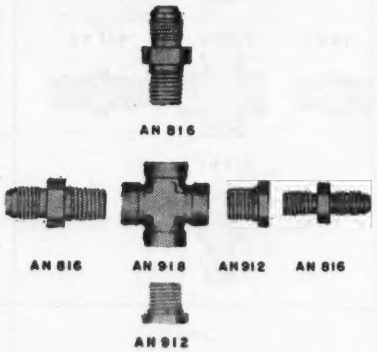
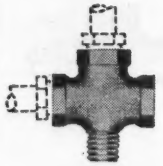
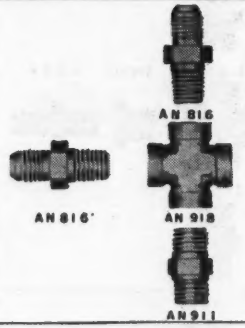
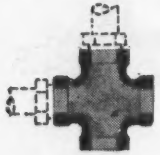
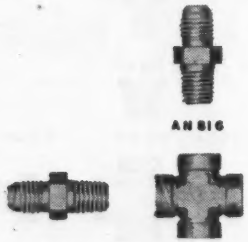
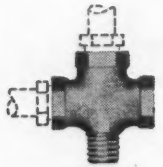
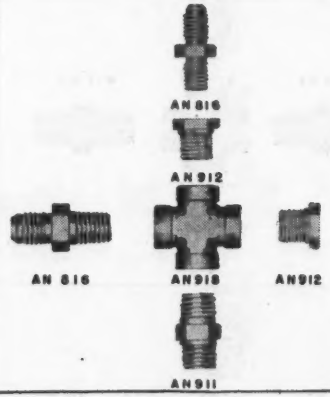
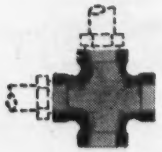
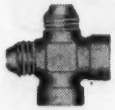
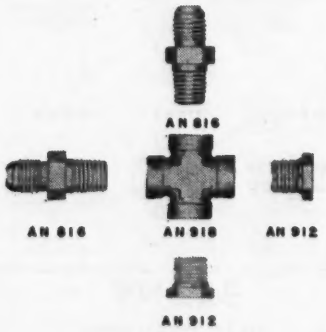
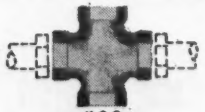
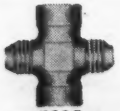
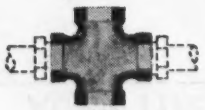
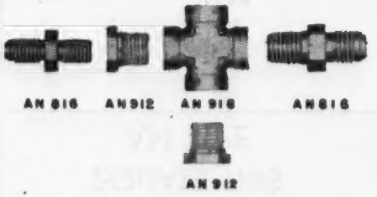
THIS AC 810 TYPE	OR THIS AC 811 TYPE	EQUALS THIS AN TYPE
RR TEE	RRT TEE	 AN 911 AN 917 AN 911 AN 816
RR TEE (COMB. SIZE)	RRT TEE (COMB. SIZE)	 AN 911 AN 917 AN 912 AN 911 AN 912 AN 816
RS TEE	RST TEE	 AN 816 AN 917 AN 911 AN 911
RS TEE (COMB. SIZE)	RST TEE (COMB. SIZE)	 AN 816 AN 917 AN 912 AN 911 AN 912 AN 911

EQUIVALENTS CHART FOR TUBE FITTINGS

THIS AC 810 TYPE	OR THIS AC 811 TYPE	EQUALS THIS AN TYPE
CROSSES		
 K CROSS	KT CROSS	AN 827
 K CROSS (COMB. SIZE)	KT CROSS (COMB. SIZE)	 AN 919 AN 902 AN 926 AN 902 AN 815 AN 902 AN 919 OR AN 816 AN 816 AN 912 AN 916 AN 912 AN 916

THIS AC 810 TYPE	OR THIS AC 811 TYPE	EQUALS THIS AN TYPE
 KS CROSS	KST CROSS	 AN 816 AN 816 AN 916 AN 816 AN 911
 KS CROSS (COMB. SIZE)	KST CROSS (COMB. SIZE)	 AN 816 AN 816 AN 912 AN 916 AN 816 AN 912 AN 911
 KO CROSS	 KOT CROSS	 AN 816 AN 816 AN 916 AN 816

EQUIVALENTS CHART FOR TUBE FITTINGS

THIS AC 810 TYPE	OR THIS AC 811 TYPE	EQUALS THIS AN TYPE	THIS AC 810 TYPE	OR THIS AC 811 TYPE	EQUALS THIS AN TYPE
 K.O GROSS (COMB. SIZE)	KOT GROSS (COMB. SIZE)	 AN 816 AN 816 AN 918 AN 912 AN 816 AN 912	 KMS GROSS	KMST GROSS	 AN 816 AN 816 AN 918 AN 911
 KMO GROSS	KMOT GROSS	 AN 816 AN 816 AN 918	 KMS GROSS (COMB. SIZE)	KMST GROSS (COMB. SIZE)	 AN 816 AN 912 AN 816 AN 918 AN 912 AN 911
 KMO GROSS (COMB. SIZE)	 KMOT GROSS (COMB. SIZE)	 AN 816 AN 816 AN 918 AN 912 AN 912	 KOO GROSS	 KOOT GROSS	AN 816 AN 918 AN 816
			 KOO GROSS (COMB. SIZE)	KOOT GROSS (COMB. SIZE)	 AN 816 AN 912 AN 918 AN 816 AN 912

EQUIVALENTS CHART FOR TUBE FITTINGS

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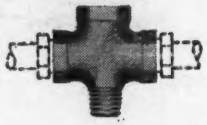
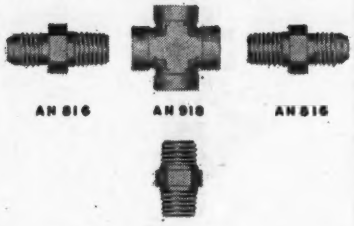
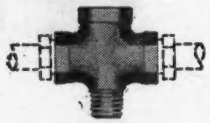
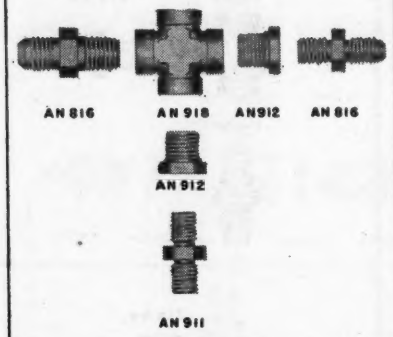
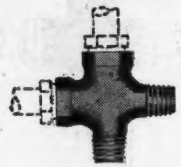
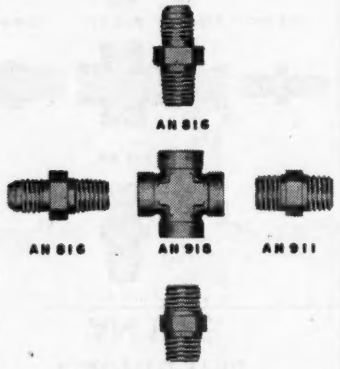
 KOS CROSS	KOST CROSS	 AN 816 AN 918 AN 816 AN 911
 KOS CROSS (COMB. SIZE)	KOST CROSS (COMB. SIZE)	 AN 816 AN 918 AN912 AN 816 AN 912 AN 911
 KRS CROSS	KRST CROSS	 AN 816 AN 816 AN 918 AN 911 AN 911

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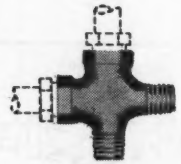
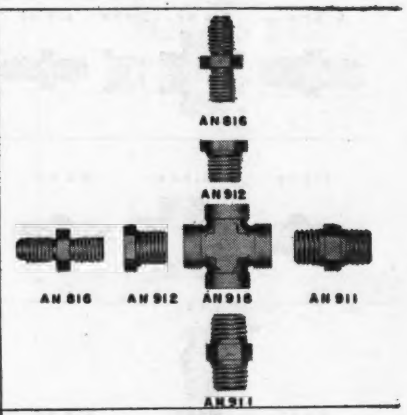
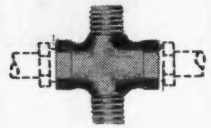
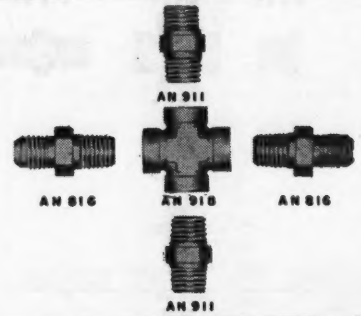
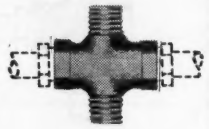
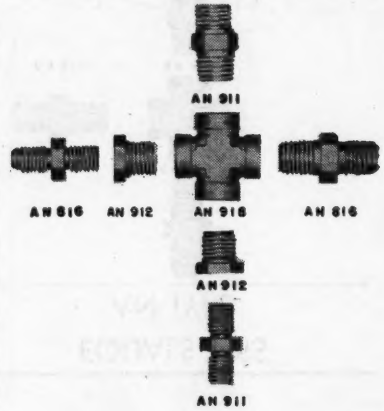
 KRS CROSS (COMB. SIZE)	KRST CROSS (COMB. SIZE)	 AN 816 AN 912 AN 816 AN 912 AN 918 AN 911 AN 911
 KSS CROSS	KSST CROSS	 AN 911 AN 816 AN 918 AN 816 AN 911
 KSS CROSS (COMB. SIZE)	KSST CROSS (COMB SIZE)	 AN 911 AN 816 AN 912 AN 918 AN 816 AN 912 AN 911

EQUIVALENTS CHART FOR TUBE FITTINGS

EQUIVALENTS CHART FOR TUBE FITTINGS

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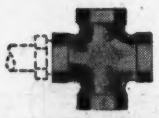
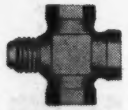
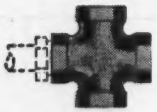
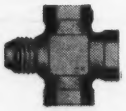
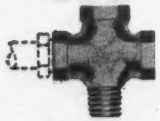
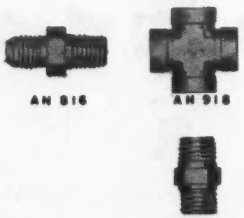
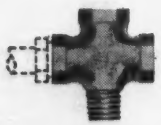
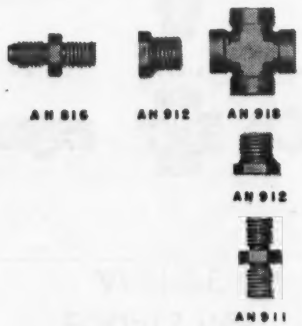
 KM00 CROSS	 KM00T CROSS	AN 816 AN 918
 KM00 CROSS (COMB. SIZE)	 KM00T CROSS (COMB. SIZE)	AN816 AN912 AN918
 KM0S CROSS	KM0ST CROSS	 AN 816 AN 918 AN 911
 KM0S CROSS (COMB. SIZE)	KM0ST CROSS (COMB. SIZE)	 AN 816 AN 912 AN 918 AN 912 AN 911

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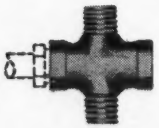
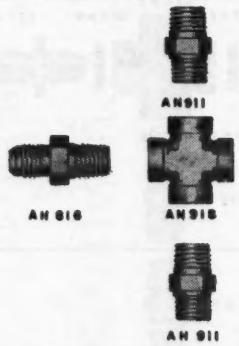
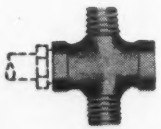
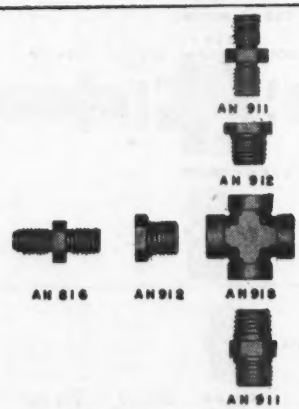
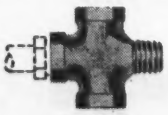
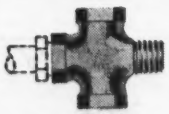
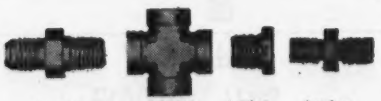
 KM5S CROSS	KM5ST CROSS	 AN911 AN 816 AN 918 AN 911
 KM5S CROSS (COMB. SIZE)	KM5ST CROSS (COMB. SIZE)	 AN 911 AN 912 AN 816 AN912 AN 918 AN 911
 KR00 CROSS	KR0OT CROSS	AN 816 AN 918 AN 911
 KR00 CROSS (COMB. SIZE)	KR0OT CROSS (COMB. SIZE)	 AN 816 AN 918 AN912 AN911

EQUIVALENTS CHART FOR TUBE FITTINGS

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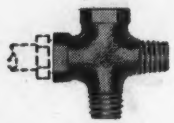
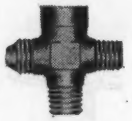
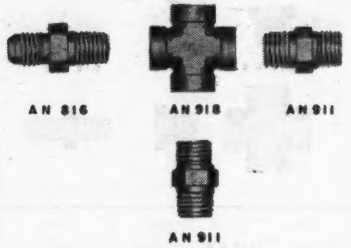
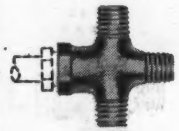
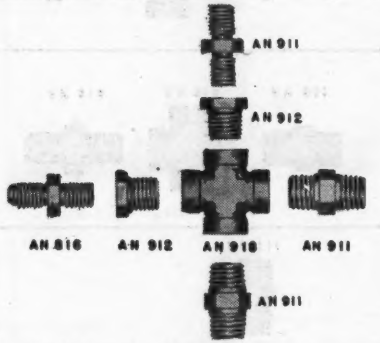
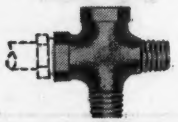
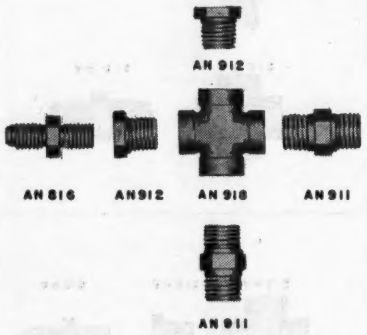
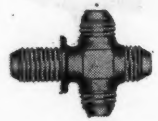
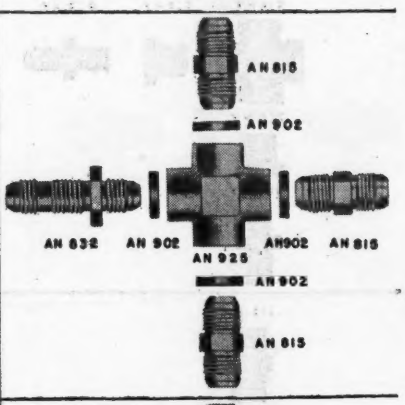
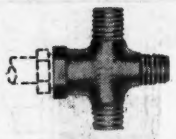
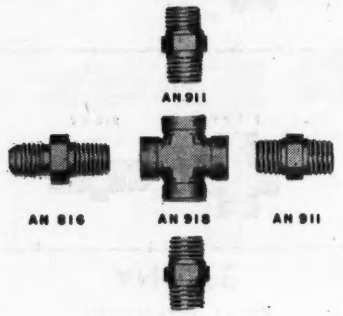
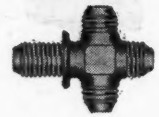
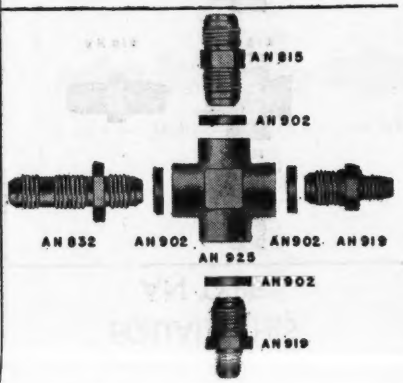
 KROS CROSS	 KROST CROSS	 AN 816 AN 918 AN 911 AN 911	 KRSS CROSS (COMB. SIZE)	KRSST CROSS (COMB. SIZE)	 AN 911 AN 912 AN 816 AN 912 AN 918 AN 911 AN 911
 KROS CROSS (COMB. SIZE)	KROST CROSS (COMB. SIZE)	 AN 912 AN 816 AN 912 AN 918 AN 911 AN 911		 KT CROSS, BULKHEAD	 AN 815 AN 902 AN 832 AN 902 AN 925 AN902 AN 815 AN 902 AN 815
 KRSS CROSS	KRSST CROSS	 AN 911 AN 816 AN 918 AN 911 AN 911		 KT CROSS, BULKHEAD (COMB. SIZE)	 AN 815 AN 902 AN 832 AN 902 AN 925 AN902 AN 919 AN902 AN 919

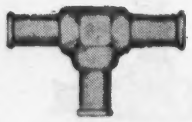
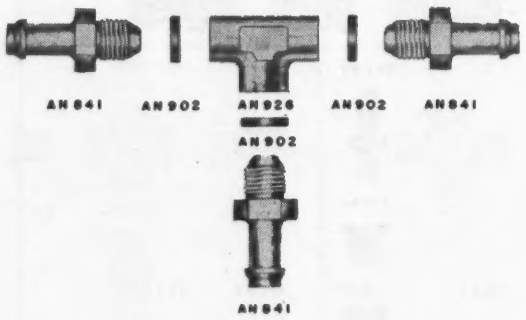
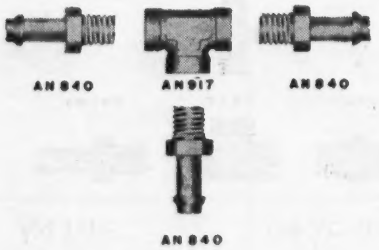
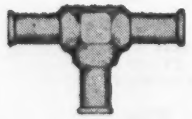
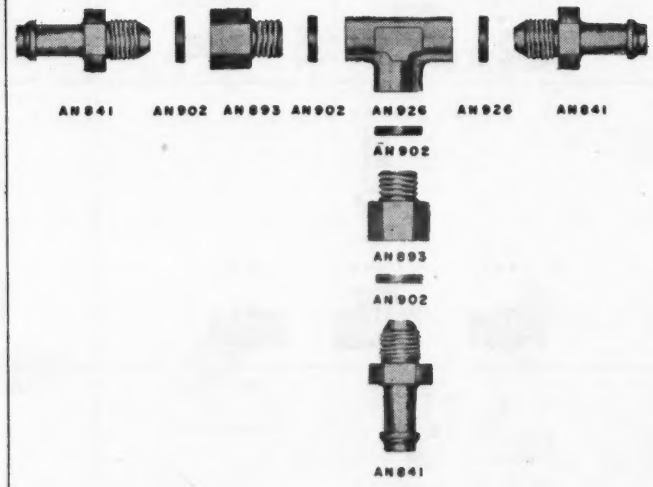
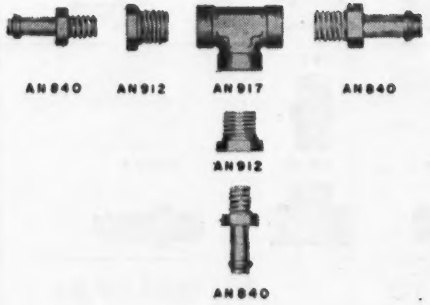
EQUIVALENTS CHART FOR TUBE FITTINGS

THIS AC 810 TYPE	OR THIS AC 811 TYPE	EQUALS THIS AN TYPE
	FLANGES	
TCB 90° TANK FLANGE	TCT 90° TANK FLANGE	AN 833 AN 902 AN 871
TCB 45° TANK FLANGE	TCT 45° TANK FLANGE	AN 837 AN 902 AN 871
TFB TANK FLANGE	TFT TANK FLANGE	AN 815 AN 902 AN 871

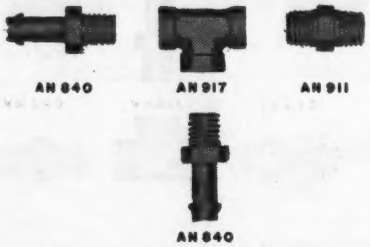
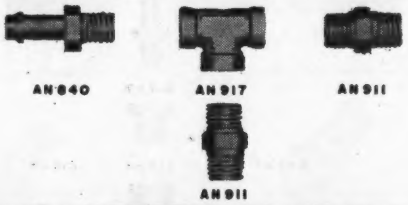
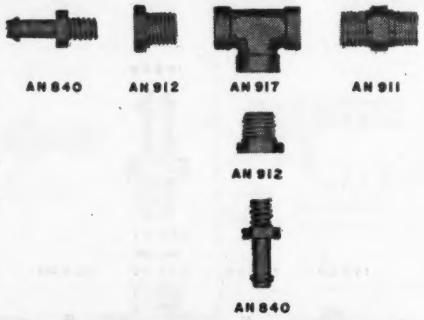
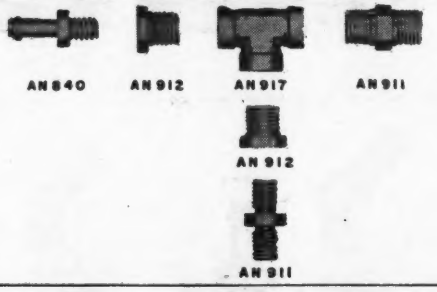
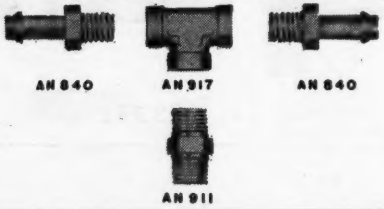
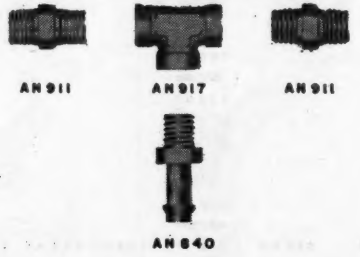
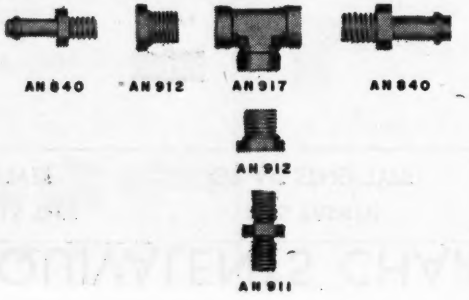
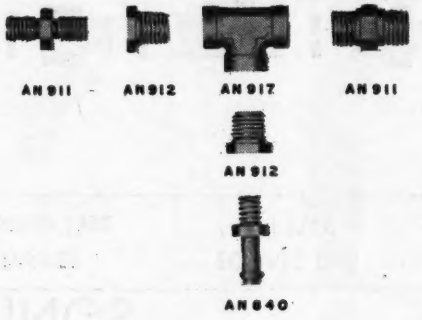
EQUIVALENTS CHART FOR HOSE FITTINGS

THIS PARKER OR AC STND. TYPE	EQUALS THIS AN TYPE	THIS PARKER OR AC STND. TYPE	EQUALS THIS AN TYPE	THIS PARKER OR AC STND. TYPE	EQUALS THIS AN TYPE
			ELBOWS		
HLF HOSE NIPPLE (AC 835)	AN 840	HLC HOSE ELBOW (AC 850)	AN 842	HLC-45° HOSE ELBOW (AC 851)	AN 844
LHLF HOSE NIPPLE (AC 836)	AN 840	LHLC HOSE ELBOW (AC 852)	AN 842	LHLC-45° HOSE ELBOW (AC 835)	AN 844
HLF HOSE NIPPLE (COMB. SIZE) OR LHLF HOSE NIPPLE (COMB. SIZE)	IF M.P.T. IS LARGER USE AN 912 AN 840 IF M.P.T. IS SMALLER USE AN 911 AN 912 AN 910 AN 840	HLC HOSE ELBOW (COMB. SIZE) OR LHLC HOSE ELBOW (COMB. SIZE)	IF M.P.T. IS LARGER USE AN 842 AN 912 IF M.P.T. IS SMALLER USE AN 842 AN 910 AN 912 AN 911	HLC-45° HOSE ELBOW (COMB. SIZE) OR LHLC-45° HOSE ELBOW (COMB. SIZE)	IF M.P.T. IS LARGER USE AN 844 AN 912 IF M.P.T. IS SMALLER USE AN 844 AN 910 AN 912 AN 911

EQUIVALENTS CHART FOR HOSE FITTINGS

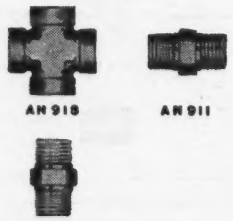
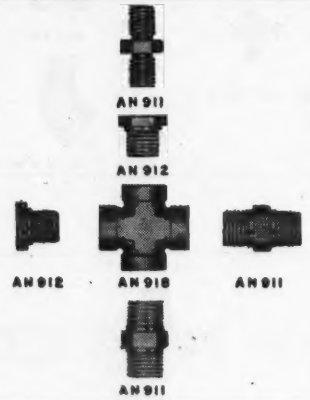
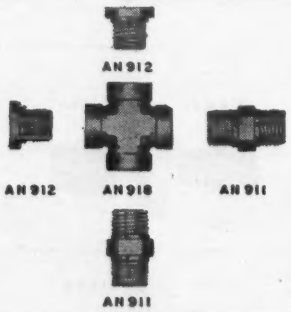
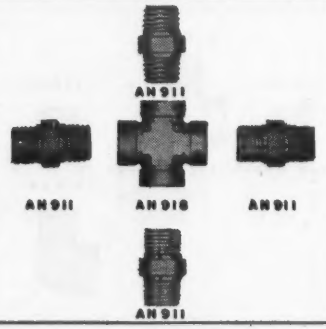
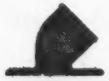
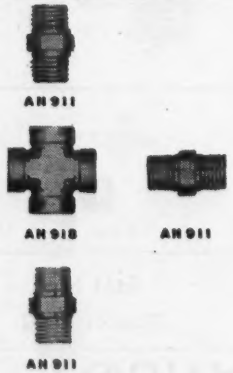
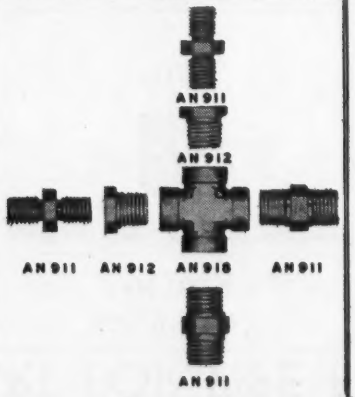
THIS PARKER OR AC STND. TYPE	EQUALS THIS AN TYPE	THIS PARKER OR AC STND TYPE	EQUALS THIS AN TYPE	THIS PARKER OR AC STND TYPE	EQUALS THIS AN TYPE
HLL HOSE LINER (AC 875)	AC 875				
TEES					
 HLJ OR LHLJ HOSE TEE	 AN 841 AN 902 AN 926 AN 902 AN 841 AN 902 AN 841 OR  AN 840 AN 917 AN 840 AN 840		 HLJ OR LHLJ HOSE TEE (COMB SIZE)	 AN 841 AN 902 AN 893 AN 902 AN 926 AN 926 AN 841 AN 902 AN 893 AN 902 AN 841 OR  AN 840 AN 912 AN 917 AN 840 AN 912 AN 840	

EQUIVALENTS CHART FOR HOSE FITTINGS

THIS PARKER OR AC STND. TYPE	EQUALS THIS AN TYPE	THIS PARKER OR AC STND. TYPE	EQUALS THIS AN TYPE
HLR OR LHLR HOSE TEE	 AN 840 · AN 917 · AN 911 · AN 840	HLRS OR LHLRS HOSE TEE	 AN 840 · AN 917 · AN 911 · AN 911
HLR OR LHLR HOSE TEE (COMB. SIZE)	 AN 840 · AN 912 · AN 917 · AN 911 · AN 912 · AN 840	HLRS OR LHLRS HOSE TEE (COMB. SIZE)	 AN 840 · AN 912 · AN 917 · AN 911 · AN 912 · AN 911
HLS OR LHLS HOSE TEE	 AN 840 · AN 917 · AN 840 · AN 911	HLRR OR LHLRR HOSE TEE	 AN 911 · AN 917 · AN 911 · AN 840
HLS OR LHLS HOSE TEE (COMB. SIZE)	 AN 840 · AN 912 · AN 917 · AN 840 · AN 912 · AN 911	HLRR OR LHLRR HOSE TEE (COMB. SIZE)	 AN 911 · AN 912 · AN 917 · AN 911 · AN 912 · AN 840

EQUIVALENTS CHART FOR PIPE FITTINGS

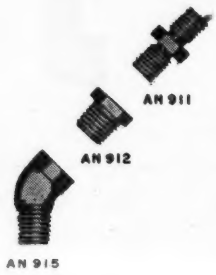
EQUIVALENTS CHART FOR PIPE FITTINGS

THIS PARKER OR AC STND. TYPE	EQUALS THIS AN TYPE	THIS PARKER OR AC STND. TYPE	EQUALS THIS AN TYPE	THIS PARKER OR AC STND. TYPE	EQUALS THIS AN TYPE
KMROS CROSS	 AN 918, AN 911, AN 911	KMRSS CROSS (COMB SIZE)	 AN 911, AN 912, AN 912, AN 918, AN 911, AN 911	FLANGES TD 90° FLANGE	AN 914, AC 867
KMROS CROSS (COMB. SIZE)	 AN 912, AN 912, AN 918, AN 911, AN 911	KRRSS CROSS	 AN 911, AN 911, AN 918, AN 911, AN 911	 TD 45° FLANGE	AN 918, AC 867
KMRSS CROSS	 AN 911, AN 918, AN 911, AN 911	KRRSS CROSS (COMB. SIZE)	 AN 911, AN 912, AN 911, AN 912, AN 918, AN 911, AN 911	TG FLANGE	AC 867

EQUIVALENTS CHART FOR PIPE FITTINGS

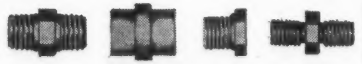
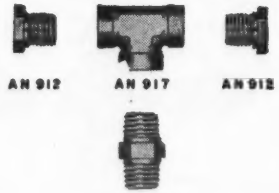
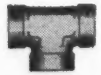
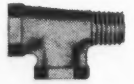
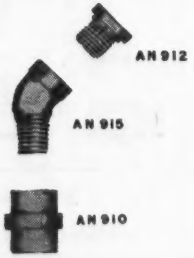
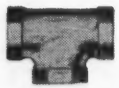
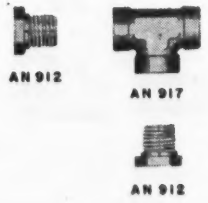
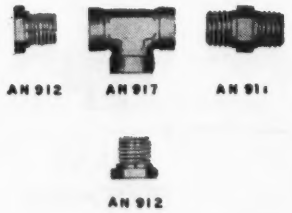
THIS PARKER OR AC STND. TYPE	EQUALS THIS AN TYPE
(AC 895-100 TO -105) PIPE PLUG (AC 895-70 TO -75)	AN 913
CAP	AN 913 AN 910
FG CONNECTOR	AN 910 AN 911
FG REDUCING BUSHING (AC 895-80 TO -88)	AN 912
GG CONNECTOR (AC 895-50 TO -54)	AN 910
GG CONNECTOR (COMB SIZE)	AN 910 AN 912

THIS PARKER OR AC STND. TYPE	EQUALS THIS AN TYPE
	ELBOWS
CD STREET ELBOW	AN 914
CD STREET ELBOW (COMB. SIZE)	IF M.P.T. IS LARGER USE AN 914 IF M.P.T. IS SMALLER USE AN 912 AN 914 AN 912
CD 45° STREET ELBOW	AN 915
CD 45° STREET ELBOW (COMB. SIZE)	IF M.P.T. IS LARGER USE AN 915 IF M.P.T. IS SMALLER USE AN 912 AN 912 AN 915

THIS PARKER OR AC STND. TYPE	EQUALS THIS AN TYPE
CR ELBOW	AN 914 AN 911
CR ELBOW (COMB. SIZE)	AN 914 AN 912 AN 911
CR 45° ELBOW (COMB. SIZE)	AN 911 AN 915
CR 45° ELBOW (COMB. SIZE)	 AN 911 AN 912 AN 915

EQUIVALENTS CHART FOR PIPE FITTINGS

EQUIVALENTS CHART FOR PIPE FITTINGS

THIS PARKER OR AC STND. TYPE	EQUALS THIS AN TYPE	THIS PARKER OR AC STND. TYPE	EQUALS THIS AN TYPE	THIS PARKER OR AC STND. TYPE	EQUALS THIS AN TYPE
DD ELBOW (AC 895-10 TO -16)	AN 916	FF PIPE NIPPLE (AC 895-90 TO -95) (AC 895-60 TO -65)	AN 911	MMS TEE	AN 917 AN 911
DD ELBOW (COMB. SIZE)	AN 916 AN 912	FF PIPE NIPPLE (COMB. SIZE)	 AN 911 AN 910 AN 912 AN 911	MMS TEE (COMB. SIZE)	 AN 912 AN 917 AN 912 AN 911
DD 45° ELBOW (AC 895-20 TO -26)	AN 915 AN 910	MMO TEE (AC 895-30 TO -36)	TEES  AN 917	 MRO TEE	AN 917 AN 911
DD 45° ELBOW (COMB. SIZE)	 AN 912 AN 915 AN 910	 MMO TEE (COMB. SIZE)	 AN 912 AN 917 AN 912	MRO TEE (COMB. SIZE)	 AN 912 AN 917 AN 911 AN 912

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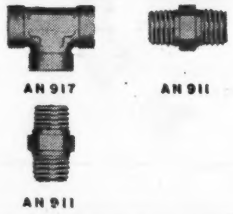
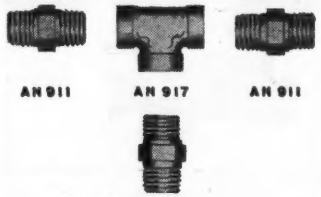
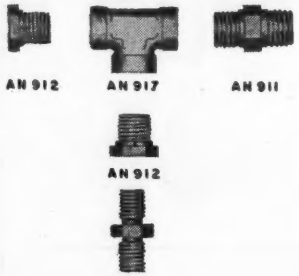
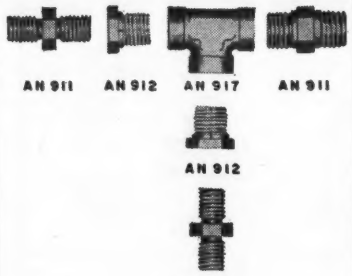
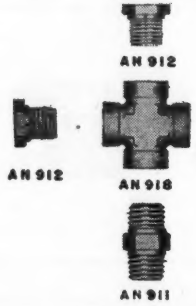
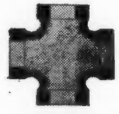
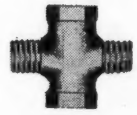
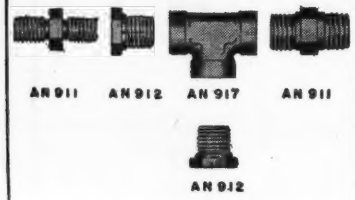
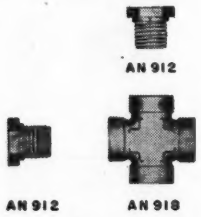
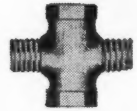
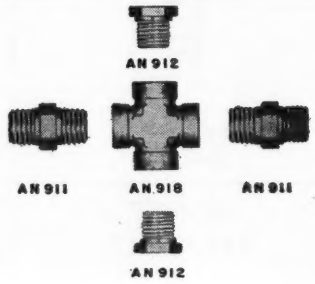
MRS TEE	 AN 917 AN 911 AN 911	RRS TEE	 AN 911 AN 917 AN 911 AN 911	KMMOS CROSS	AN 918 AN 911
MRS TEE (COMB. SIZE)	 AN 912 AN 917 AN 911 AN 912 AN 911	RRS TEE (COMB. SIZE)	 AN 911 AN 912 AN 917 AN 911 AN 912 AN 911	KMMOS CROSS (COMB. SIZE)	 AN 912 AN 912 AN 918 AN 911
RRO TEE	AN 911 AN 917 AN 911	 KMMOO CROSS (AC 895-40 TO -46)	CROSSES AN 918	 KMMSS CROSS	AN 911 AN 918 AN 911
RRO TEE (COMB. SIZE)	 AN 911 AN 912 AN 917 AN 911 AN 912	KMMOO CROSS (COMB. SIZE)	 AN 912 AN 912 AN 918	 KMMSS CROSS (COMB. SIZE)	 AN 912 AN 911 AN 918 AN 911 AN 912

LOOKING AHEAD TO AIR CARGO MARKETS

PART II

By **ROBERT K. KINZEL**

Outlining basis for establishing volume-building commodity rates, together with essential policies to build sales and service organizations needed to get and hold "real" cargo tonnages.

ONE OF THE BIG PROBLEMS of aviation has been to increase payload factors. Before the war, domestic American lines were operating in most cases, on a load factor of less than 60 percent.

This did not mean that planes were going out only 60 percent loaded but rather that passengers and cargo were being dropped at stops along the route with not enough new passengers or cargo being loaded to keep the plane full.

The airplane's inflexible load-carrying capacity has, of course, been one of the major hurdles in the load factor picture; the airlines have not enjoyed the railroads' ability to "add another car" to take care of peak loads. One answer to this load factor problem is—on routes with sufficient traffic—to run several sections of a flight.

Thus, if there were five sections or planes for a given flight, the first four would be fully loaded, then the fifth would take the overflow, giving an overall load factor of, say, better than 80 percent. As the flight progressed, the number of sections could be reduced, even to the point of having but one plane complete the entire distance. At the same time, the number of planes could be increased wherever the traffic proved heaviest.

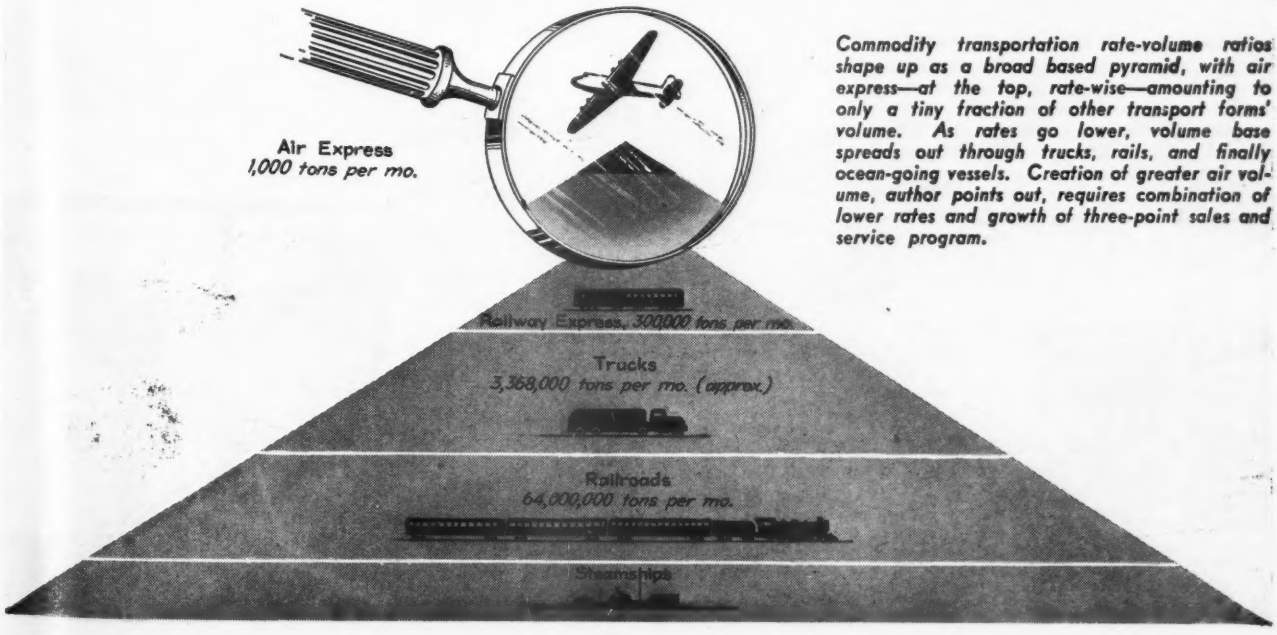
Outside of the United States, it is only since the war that service has been increased to daily flights from Miami down both the East and West Coasts of South America to Buenos Aires. In the Pacific, Singapore, Hongkong, and New Zealand were, prior to the war, served but once a week. It can thus be readily seen that cargo will have to be added to passenger and mail loads—as is usually done today—both to help increase frequency of flights by raising the load factor and to add extra sections.

To illustrate why the all-cargo plane will not immediately come into general use, let us analyze the plane requirements in the domestic field, where it is expected air traffic will first attain a high density. Based on a rail express market of about $200,000,000 per year, let us assume that 40 percent, or $80,000,000, moves by air (no small assumption, to be sure). At 15c. per ton-mile this would equal 533,000,000 ton-miles.

Further assuming that postwar cargo planes will have at least 7 tons payload, 200-mph. cruising speed, and can be operated 10 hr. a day, each plane could thus be counted on for 14,000 ton-miles per day, or 4,200,000 ton-miles over 300 days. Going back to the prewar 60 percent load factor, the net ton-miles per plane would be 2,520,000. On this basis, 210 planes would be capable of moving the entire business developed.

Such a small number of planes could not, of course, give the desired frequency of service. This, coupled with the fact that on many routes there would not be sufficient cargo business to warrant use of 7 ton-payload craft, would necessitate the use of smaller craft or combination passenger-cargo planes.

With some of the general outlines of the air cargo structure outlined, we now come to the core of the commercial problem: What must the airlines do to get the potential cargo business, conserva-



Commodity transportation rate-volume ratios shape up as a broad based pyramid, with air express—at the top, rate-wise—amounting to only a tiny fraction of other transport forms' volume. As rates go lower, volume base spreads out through trucks, rails, and finally ocean-going vessels. Creation of greater air volume, author points out, requires combination of lower rates and growth of three-point sales and service program.

tively estimated at a minimum of ten times the prewar volume, at rates but a quarter as high?

Obviously, business won't come in by itself; a constructive sales and service policy is essential, a policy embracing four essential points.

The first covers ground service. Adequate, speedy pickup and delivery are both essential, not only to maintain the advantages of speed inherent to air transport, but to meet competition of surface transportation. In this country, the Railway Express Agency, with an investment of some $26,000,000 in equipment and vehicles, has ample facilities, not only for quick pickup and delivery at airport cities but, through its rail service, to forward shipments to and from all points with rail service—some 23,000 cities and towns.

There is, however, a possibility that the domestic airlines may not continue indefinitely their contracts with REA, in which event it will be necessary to offer comparable service, either through a large over-all pickup and delivery organization or by agreements with smaller companies in individual cities or areas.

The foreign field has such a variety of ground services—or lack of them—that generalizations are impossible. In some places pickup and delivery are available; in others the shipper himself must get his consignment to or from the airport.

In Europe, it is believed that little difficulty should be encountered in making tie-ups with railroads for pickup and delivery. In other parts of the world, though, it is apparent the airlines will have to establish their own local trucking services which, if efficiently managed, should prove a very profitable adjunct.

It is evident that, with both ground and air competition constantly increasing, adequate ground service will have to be offered if the airlines are to make sizable penetrations in the express and cargo fields. As an example of the importance of this service, a Cuban importer recently reported he specified that all shipments under 200 lb. be sent him by air express, solely because of the efficient delivery service offered by the airline in Havana. He felt that in the long run he was saving money by paying air express rates and getting prompt store-door delivery at a modest charge, rather than having to send his own truck on a special trip and make his driver go through all the red tape of getting the shipment through customs and to the plant.

The second major policy covers what might well be called the service division, which would be established as part of the sales department. A large percentage of the shippers who use air service regard transportation as a minor part of their business. To them transportation is an evil necessary to complete their sales; it is a nuisance they try to minimize by seeking the easiest way to ship.

The type of shipping service which will gain and hold customers must permit this easiest way of shipping. Tariffs must be easy to understand, thus giving the cargo service man an entree. Shipping departments always have small questions which can be readily answered by service men—items such as complaints about pickups or tardy settlements of claims; questions on whether lighter packing might be used or what documents are required in certain countries; or an explanation of liability coverage or insurance under the bill of lading.

A large group of airline cargo service men could easily be kept busy visiting thousands of potential shippers and going over individual problems of new personnel in shipping rooms of regular shippers. But in addition to their straight "service" work, these men could also do considerable selling and, most important, keep management informed of potential business which can be solicited by trained specialists.

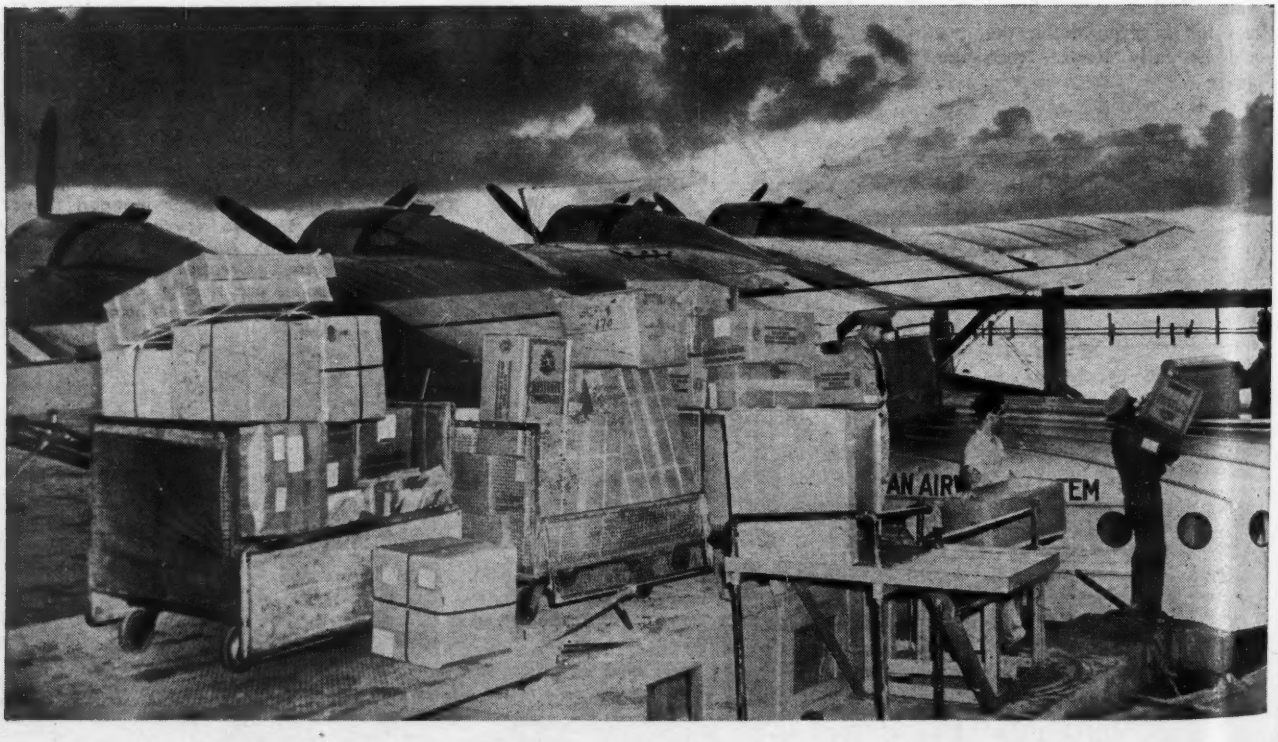
The third major policy involves consistent advertising to back up both the trained sales specialists and the service men. Although air express has been available for 15 yr., informal surveys have shown that almost no shipper can estimate its cost within 10 percent. Nor are there more than a very rare few who can give accurate estimates on air transportation's time saving ability. Even fewer realize that documents required for air shipments are much simpler than those required for ocean transport; that Cuba, Mexico, Brazil, and Trinidad required no documents for goods moving by air.

These are but a few of the major points providing advertising themes. The service mens' reports will uncover any number of other features by which advertising can promote air shipments.

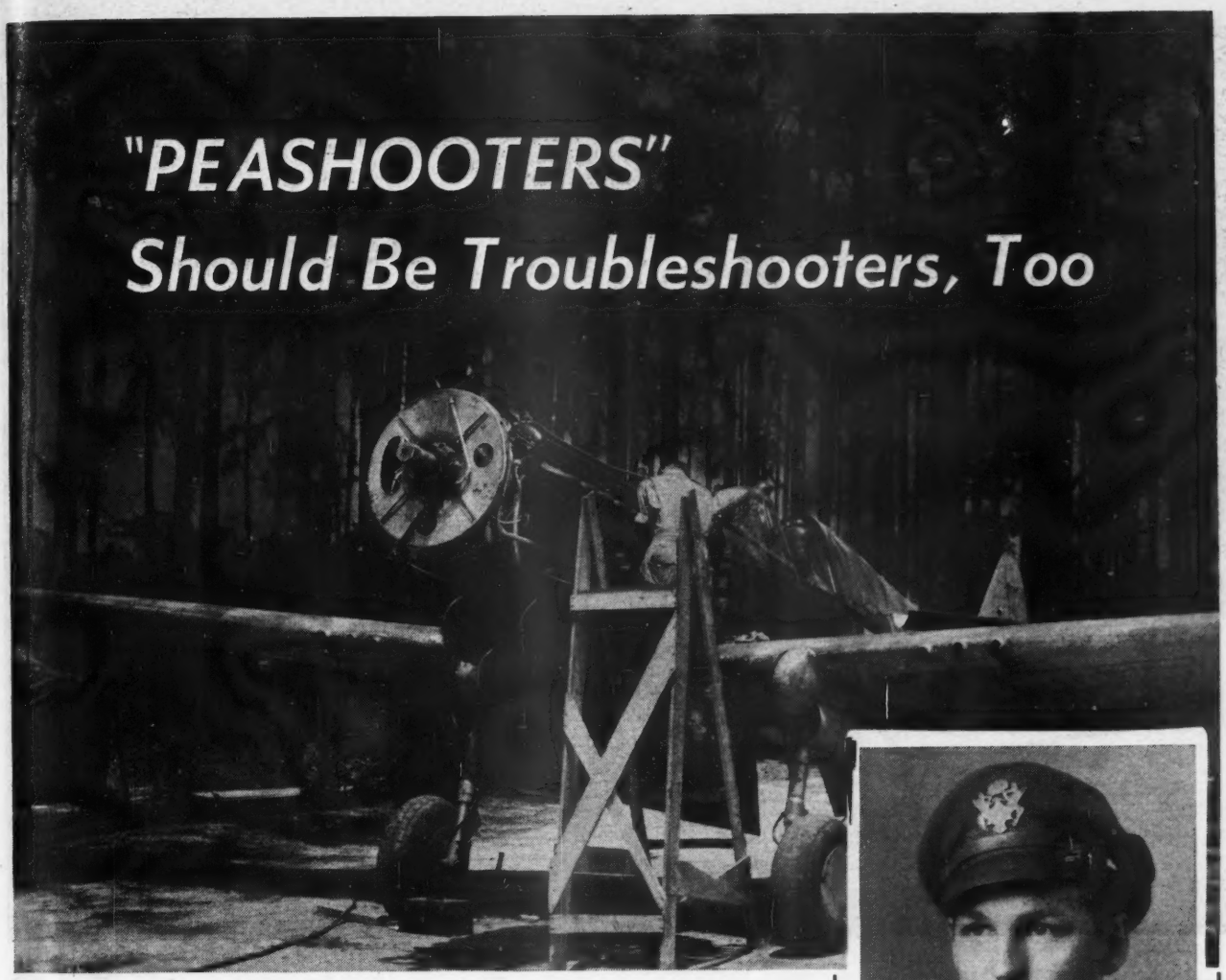
The fourth major policy involves commodity rates. The new business which the airlines must and shall develop will obviously require specially trained salesmen of high caliber, for on their shoulders will fall the major responsibility of getting volume business, business which it

(*Turn to page 267*)

Though cargo business will develop rapidly, visionaries' dream pictures of huge fleets of cargo planes are felt to be far in future—in fact it is believed that combination passenger-mail-cargo type craft will continue in use for some years.



"PEASHOOTERS" Should Be Troubleshooters, Too



By John S. Miller, *1st Lt., Air Corps*

Fighter pilots share an important responsibility with their crew chiefs in keeping aircraft in operation against the enemy. Here are some important tips for new battlefront pilots—tips which will serve them and their squadrons well.

A PLANE that cannot be "put on alert" is not worth a damn to anybody at a front-line fighter base. In the South Pacific area there never has been a surplus of airplanes, and each one in fighting shape seems more precious than life itself to the personnel operating in that theater.

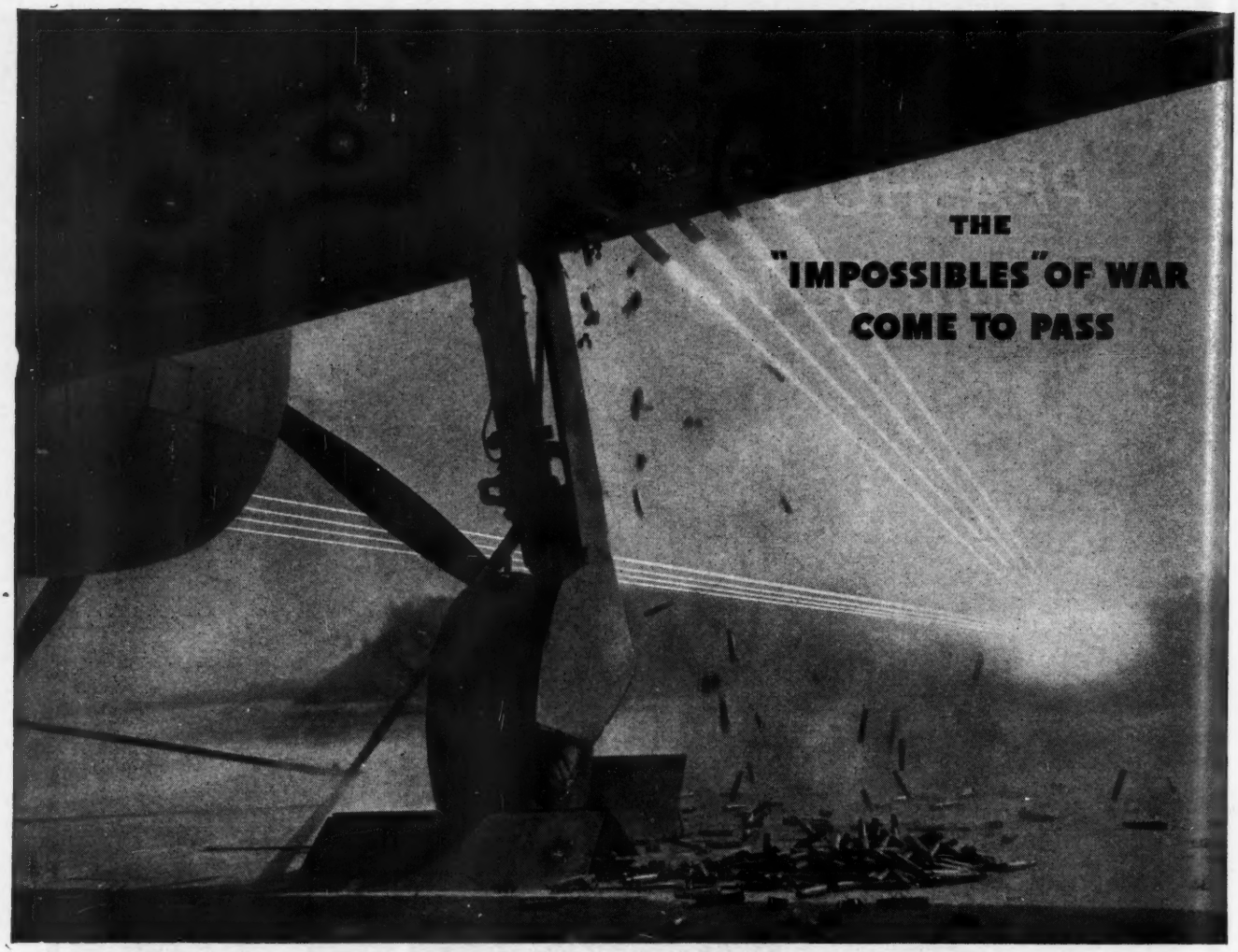
In short, whatever it takes to keep equipment in flying condition assumes more importance than almost anything else. Accordingly, practically everybody is maintenance-minded—and if the fighter pilot isn't, he *should* be.

Few people think of the pilot as a factor in maintenance, and in many cases not enough pilots are fully aware of their importance to the maintenance function. The pilot has a perfect right to expect his plane to be kept in top-notch condition—but the crew chief, like the doctor with his patient, can do his job best when the pilot, who is experiencing the trouble, helps with the diagnosis and (when feasible) with the cure.

The essentials of keeping equipment operating against the enemy are few but intricate within themselves. First, the equipment must be of rugged design and inherently trouble-free. Second, supply must be established as the life blood of operations. A highly trained maintenance organization is a mockery without adequate provision for spare parts supply. The third factor combines the flight crew and ground crew on the line. Neither crew can work alone to get the desired results; teamwork is the essential operating requirement.

The fighter pilot is busier than the proverbial one-armed paper hanger. In flight he is, to take a bomber crew for analogy, the pilot, co-pilot, bombardier, gunner, avigator, radio operator, and flight engineer all wrapped into one. Generally speaking, only the combat-ex-

LT. MILLER returns from 17-months duty as a fighter pilot in the Southwest Pacific with sober thoughts on the less glamorous, but nonetheless important, responsibilities of a combat pilot operating from front-line flight strips. Member of a Group twice cited by the President (more enemy aircraft were shot down by this Group than by any other in the Air Forces), he credits much of the excellent combat performance to fine cooperation between pilots and crew chiefs. He reports that the bulletins most prominently displayed in the operations shacks were servicing reports. Lt. Miller firmly believes that there was a lot more than coincidence in the establishment of both an astonishing Group combat record (over 400 aircraft) and an outstanding maintenance record.



"WE must some day be able to see enemy targets through the thickest fog and the blackest night . . . a single American soldier must be made a match for an enemy tank . . . we must be able to land armies upon every kind of fortified coast . . . we must send fighter planes seven miles into the sky, if need be, to smash enemy bombers from above . . ."

Thus read the notebooks of military strategy, not so long ago, listing things of war that were out of this world . . . the "impossibles" of the peacetime Sunday supplements.

But war is a relentless taskmaster. And so today we have a parade of "impossibles" of amazing variety—radar, the bazooka, unique troop landing craft . . . and an airplane that fights seven miles up, dives at speeds approaching the speed of sound, spits out more than ten pounds of steel projectile per second!

That airplane is the Thunderbolt — the joint product of an A.A.F. Matériel Command that knew what it wanted . . . and a corps of Republic engineers who knew it could be done. It is out of many such combinations that this nation is becoming invincibly armed . . . and its aerial supremacy made secure for the future.

Not the least "impossible" aspect of the Thunderbolt was its *production*. How could so intricate and elaborate a machine ever reach "quantity production"?

Yet, in a recent month, more planes came off the Republic Thunderbolt assembly lines than came from the assembly lines of any other company in America producing fighter-type aircraft.

Republic, along with every other war material manufacturer, working hand in hand with the Army Air Forces, is ready for still more "impossibles." Republic Aviation Corporation, Farmingdale, L. I., New York, and Evansville, Indiana.

Republic *firsts* in war point to *firsts* in peace

Thunderbolt

REPUBLIC AVIATION

CORPORATION

Specialists in High-speed, High-altitude Aircraft

FARMINGDALE DIVISION

Write that boy today — V-Mail

perienced fighter pilot realizes how much of a "flight engineer" he has to be to get the best operating results. Actually, the only difference between himself as a flight engineer and the bomber flight mechanic is that he is not required to do the actual repair and servicing work.

However, his responsibility does not end with saying to the crew chief, "The damned thing doesn't run right." His salvation, in fact, may depend on telling his crew chief precisely and accurately which specific part is not functioning correctly, and the more he knows about *why* it is malfunctioning (and in many cases, what to do about it) the better the entire operating team will function.

Excluding the supply factor, the smallest self-contained combat unit in a fighter command is the squadron. The team nucleus is the fighter pilot and his crew chief, who are directly responsible for employing the fighter plane to best advantage against the enemy. The crew chief and his assistant are expert technicians capable of servicing all working parts of the aircraft, including both rigging and engine. In charge of the crew chiefs is the line chief, who is consulted when any special difficulties are encountered. An engineering officer directs all maintenance functions of the squadron, and he reports directly to the squadron commanding officer.

The pilot is in supreme command of his airplane, both in the air and while on the ground, except when the plane is grounded by the inspector or engineering officer. He reports to the operations officer who, in turn, reports to the squadron C. O.

Paperwise, the principal liaison instrument in this setup is Form 1-A—the engineering report on the airplane which records its status at all times (see Fig. 2). Filled out, this form represents the "on the record" interchange of information between the pilot and crew chief. Theoretically, the space designated, "Remarks: Pilot and Mechanics," is where the pilot tells the crew chief "all about it" when he returns from a flight. He does, in fact, briefly jot down his story for the record. However, many maintenance man-hours may be saved by taking a little more time—i.e., sitting down and thinking and talking the thing through with the crew chief.

By virtue of the fighter plane's "accommodations," the crew chief is generally never there when the trouble develops. Always on the ground, he depends entirely on what the pilot tells him. It follows, then, that the fighter pilot must learn to be a troubleshooter—and the better he becomes at it, the quicker the trouble can be corrected.

In complex machines such as the modern combat plane, there is a very involved inter-relationship between mechanism and system. Failure or malfunctioning indicated at one point may be *caused* at an entirely different location. For example, fluctuation of the tachometer may indicate propeller surging—and the pilot, after observing such tach hopping, may cut short his mission and return to his field. But such trouble may actually lie in a faulty tachometer, and if that's the case the time taken to dismantle the propeller must be credited to the enemy's advantage. A more alert pilot could tell by watching and listening to the propeller that the instrument indication was in error.

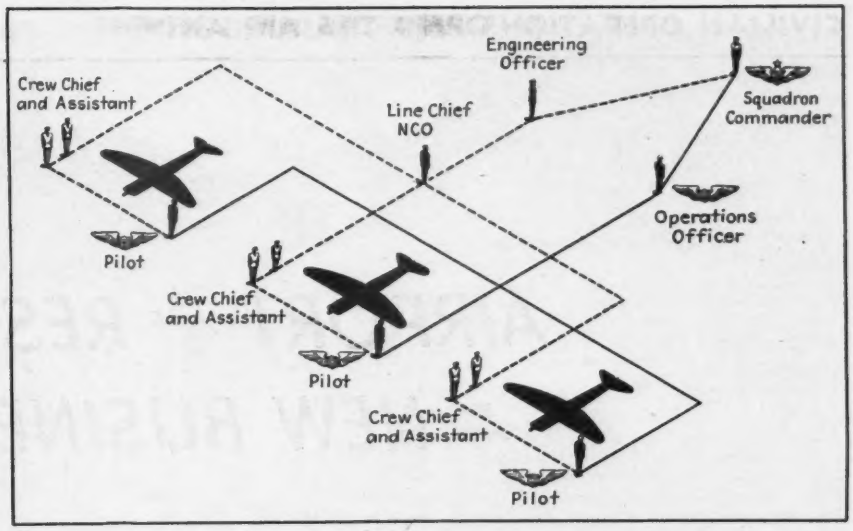


Fig. 1. Diagram of fighter squadron elements showing relationship of members. To each aircraft is assigned a pilot, crew chief, and assistant to crew chief. Pilot reports to commanding officer through operations officer. Crew chiefs are supervised by line chief, who reports to engineering officer.

Each airplane has its idiosyncrasies, and a pilot who learns to spot the difference between them and real trouble will save a great deal of servicing time. A ship may develop strange sounds, the engine may run roughly, or some of the instruments may be a little off. With a little experience the pilot can learn to recognize them as nothing serious and accordingly he will not order the plane off alert when it may be badly needed. He can save the crew chief a lot of needless work (the man's plenty busy anyway) if he tells him about such plane characteristics so that a new pilot flying the plane can be informed properly and not return from an incompleted mission with orders for a thorough check.

A great deal of mechanical trouble is just plain pilot trouble. Many are the hours put in by the crew chief trying to

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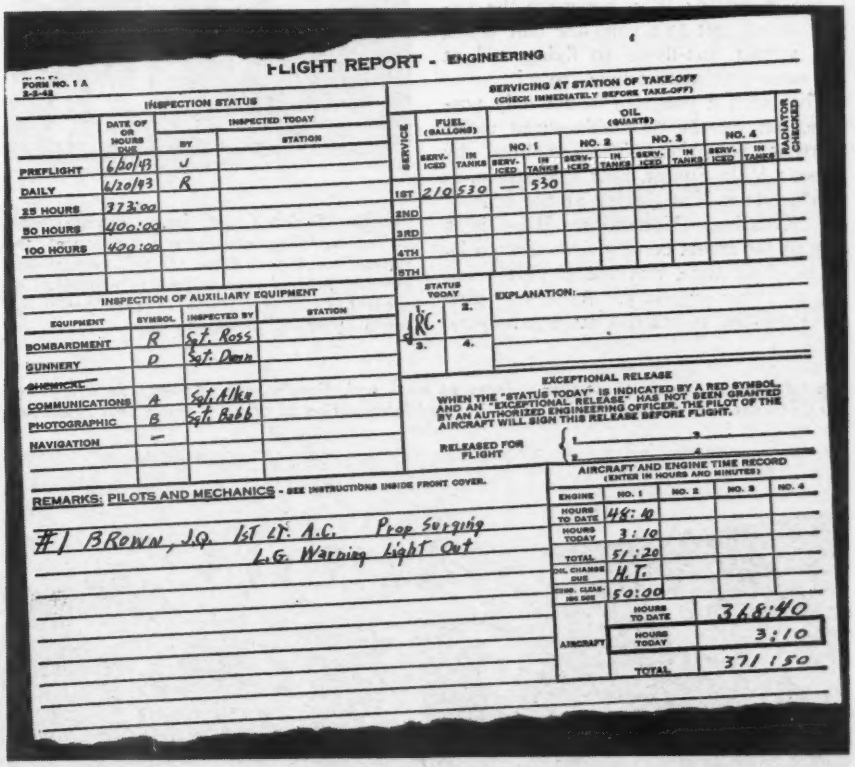


FLIGHT REPORT - ENGINEERING

FORM NO. 1 A
5-5-43

INSPECTION STATUS

	DATE OF OR HOURS DUE	INSPECTED TODAY BY	STATION
PREFLIGHT	6/20/43	J	
DAILY	6/20/43	R	
25 HOURS	373:00		
50 HOURS	400:00		
100 HOURS	400:00		

INSPECTION OF AUXILIARY EQUIPMENT

EQUIPMENT	SYMBOL	INSPECTED BY	STATION
BOMBARDMENT	R	Sgt. Ross	
GUNNERY	D	Sgt. Dunn	
~~CHEMICAL~~			
COMMUNICATIONS	A	Sgt. Alke	
PHOTOGRAPHIC	B	Sgt. Babb	
NAVIGATION	—		

SERVICING AT STATION OF TAKE-OFF
(CHECK IMMEDIATELY BEFORE TAKE-OFF)

SERVICE	FUEL (GALLONS) SERV-ICED	FUEL (GALLONS) IN TANKS	OIL (QUARTS) NO. 1 SERV-ICED	OIL NO. 1 IN TANKS	OIL NO. 2 SERV-ICED	OIL NO. 2 IN TANKS	OIL NO. 3 SERV-ICED	OIL NO. 3 IN TANKS	OIL NO. 4 SERV-ICED	OIL NO. 4 IN TANKS	RADIATOR CHECKED
1ST	210	530	—	530							
2ND											
3RD											
4TH											
5TH											

STATUS TODAY: 1. RC 2. 3. 4.

EXPLANATION:

EXCEPTIONAL RELEASE

WHEN THE "STATUS TODAY" IS INDICATED BY A RED SYMBOL, AND AN "EXCEPTIONAL RELEASE" HAS NOT BEEN GRANTED BY AN AUTHORIZED ENGINEERING OFFICER, THE PILOT OF THE AIRCRAFT WILL SIGN THIS RELEASE BEFORE FLIGHT.

RELEASED FOR FLIGHT 1. 2. 3. 4.

REMARKS: PILOTS AND MECHANICS - SEE INSTRUCTIONS INSIDE FRONT COVER.

#1 BROWN, J.Q. 1st LT. A.C. Prop Surging
L.G. Warning Light Out

AIRCRAFT AND ENGINE TIME RECORD
(ENTER IN HOURS AND MINUTES)

ENGINE	NO. 1	NO. 2	NO. 3	NO. 4
HOURS TO DATE	48:40			
HOURS TODAY	3:10			
TOTAL	51:20			
OIL CHANGE DUE	H.T.			
ENGINE CLEANING DUE	50:00			

AIRCRAFT	
HOURS TO DATE	368:40
HOURS TODAY	3:10
TOTAL	371:50

Fig. 2. Form 1-A is engineering report on aircraft. It is the instrument through which pilot reports mechanical troubles to engineering section of squadron.

AIRPORT + RESORT = NEW BUSINESS

Making private flying facilities an integral part of larger operation, such as year-'round country hotel, can assure operators a steadier income. Here's the case history of an air-resort that has survived the war and looks forward to expansion.

As PRIVATE FLYING has developed thus far, the airport has been a unit *per se*—it has been the attraction around which have clustered "side shows" that have, in too many cases, been so shoddy as to discourage patronage of people who could and would like to do business with aviation operators.

Future growth of private flying demands a vast expansion in the number of landing facilities, which brings up this logical question: Why not make the airport an adjunct to a complete unit which will attract non-flyers to flying and at the same time attract flyers to it?

That such a program is not only possible, but can be profitable—even under wartime conditions—is exemplified by Rocco's Villa Sunset, near Blairstown, in northwestern New Jersey at the base of the Kittatinny Mountains. Here is a case of the resort coming first, though by but a short time, and the airport being set up as an auxiliary. As it has been managed, the resort has attracted flyers, and the flying has attracted other patrons.

First unit of the Villa was built in 1927 overlooking Lake Susequehanna, which lies adjacent to a good sweep of level ground just five minutes walk from the lodge. R. B. Bunino, the proprietor, was and is a flying enthusiast, which meant but one thing — use of that level ground as an airport. Two small, inexpensive lean-to hangars served as the nucleus for flying activities that, for a time, were largely confined to spring and summer week ends.

"Rocco" Bunino (right, facing camera) welcomes a flying guest to Villa Sunset for summer week end. Plans for this airport—an integral part of resort—include expansion of present 2,100 ft. runway in anticipation of rapid growth of private flying.

Meanwhile, development was pushed on the main portion of the resort to build it into a year-'round operation, with today's capacity standing at approximately 50 over-night guests. Naturally, the largest volume of prewar business was in the summer time, with swimming, boating, flying, and just keeping cool the main attractions. However, the Villa's location made it possible to develop a good sportsmen business, for the hunting season opens around October 1.

This was followed by the winter sport season, with a tobaggan slide, ski tow, and ice skating facilities giving all the desired variety. Again location played an important part in the development, for the fishing season, running from April through September, brought numerous additional guests.

One of the principal reasons for steady growth and repeat patronage has been due to the owner's continued maintenance of a good kitchen; Sunset's reputation for consistently excellent food spread out not

Typical prewar line-up of personal planes on week end. Guests have been attracted to resort by flying facilities, and introduction of other guests to flying has helped attract new devotees to aviation with result that resort has done consistently better business.

A year-'round resort, known for its food and accessibility to hunting and fishing, Villa Sunset, has added private flying as a vital, but not all-important, adjunct. Used for a time as a WTS flying school, Villa Sunset has helped keep private flying alive through war years.

only to a comfortable driving radius but, in many cases, to week-end flying range.

Instead of killing the Villa's aviation business, the war has in fact brought additional development. When the WTS program was in need of more and more facilities, the lodge was closed to the public and became a flying school from which two good sized classes were graduated.

To accommodate this flight training program, a 60 by 80-ft. hangar and a 30 by 40-ft. shop were built. Moreover, the field itself was improved; it is currently 800 ft. wide by 2,100 ft. long, with unobstructed approaches from both ends. Additional stump clearing is planned for the near future, which will extend the field to 2,300 ft. in length.

Completion of the WTS program did not, however, put an end to flying activities. Since the field is just outside the "sensitive zone" which the Army closed to private flying, the field became the base for nine personal aircraft owners who wanted to keep up their time. Meanwhile, a deal was worked out with a fixed base operator, who thereupon moved three planes to the Villa's field.

These craft have been kept busy, especially on week ends, both for dual instruction and solo flying. For instance, one group of five aircraft plant workers each week spend their day off at Sunset, building up flying time, enjoying good food, and relaxing. The location has been a favorite of Civil Air Patrol members; they received a special welcome the first time the field was used as a base for maneuvers, and many have come back every available week end to get in flight time.

Although Villa Sunset could be operated successfully without flying, there is no intention of dropping these facilities, the owner told AVIATION. In fact, he points out, private flying will be developed even more in the future as an integral part of the resort's operations. "Heretofore most of our patrons have come by automobile," he said, "and since the airplane offers a much greater range, we will make every effort to secure our share of the business which will be made possible by the expansion of private flying."

On the basis of this one successful operation of an airport as an auxiliary, it need not be assumed that every fixed base operator should or must become a resort owner or similar type of businessman—any more than that every innkeeper should or must become an airport operator. But the fixed base operator who does set his operations up so that flying becomes an integral part of a multi-faceted business, or who teams up with someone who has such an enterprise, stands to make more than a bare living over a longer period of time.

Ski tow at Villa Sunset, near Blairstown, N. J. With privately owned airport open for year-'round operations, future guest list is expected to grow in proportion to growth of private flying.

Intercooling Problems in Airplane Design*

By HOLLEY B. DICKINSON
Lockheed Aircraft Corporation

THE CAPACITY of the charge-air cooling system is generally limited to the absolute minimum that will permit the utilization of the engine and supercharger capacity to the desired degree under the most severe atmospheric conditions at which operation is necessary. Since this usually requires an intercooler larger than the optimum for typical atmospheric conditions, the determination of optimum intercooler size has little significance to the airplane designer.

Many of the factors which enter into the selection of the type and capacity of charge-air cooling installations are difficult to subject to quantitative analysis. Among these are problems of simplicity, maintenance, accessibility, and arrangement of the engine installation. In general, however, the difficulty of installation of the charge-air system is out of proportion to the core size. The weight increase due to the system, for instance, is in the neighborhood of five times the weight of the air-to-air intercooler core.

The use of a liquid-to-air aftercooler system as opposed to an air-to-air intercooler system shows promise only in applications with liquid-cooled engines where the separation of the ultimate cooling unit from the rest of the installation is a definite arrangement advantage.

From the standpoint of the airframe designer, the purpose of charge-air cooling is to increase the effectiveness of the airplane in accomplishing the operations for which it is designed. This is the ultimate yardstick which must be applied in answering three fundamental questions:

1. Whether charge-air cooling is to be employed
2. How the cooling is to be accomplished
3. To what extent the charge air is to be cooled.

It is immediately apparent that these are very complex questions. They involve not only the engine performance, but also the aerodynamic effect of the weight and of the internal and external drag of the coolers. They involve questions of maintenance, accessibility, and servicing. Often production, tooling availability of purchased equipment, and cost enter. Certainly, if time were taken to subject all of these factors to careful analysis in a particular case, the design would be obsolete before it flew. Much must be left to the individual judgment.

It is not the intention to attempt an original contribution to the problem, but to describe, and superficially, at least, to analyse current practice. The author does not propose to dismiss any of these problems on the basis of the qualitative discussion and brief quantitative data included, but rather merely to express what must sometimes seem to be the obstinate viewpoint of the designer.

When is Charge-Air Cooling Desirable?

The first problem which confronts the airframe designer is whether charge air cooling is to be employed. At first glance, this may seem an almost trivial question, and indeed in most cases the answer is obvious. For example, an installation in a fighter airplane designed for maximum power operation at 30,000 ft. may employ an engine which requires a pressure at the carburetor of 35 inches of mercury and, to avoid detonation, a temperature at that point of not more than 100 deg. F. Since the auxiliary-stage supercharger must raise the induction system pressure from about 9 inches of mercury to about 37 inches of mercury, the carburetor air temperature without intercooling would

(*Turn to page* 278)

* From a paper presented before the S.A.E., April, 1944.

REFERENCES

1. Colman, Philip, "Temperature Effects on Turbine Supercharger Installations," J. Ae. S., Vol. 10, No. 8, October, 1943.
2. Hives and Smith, "High Output Aircraft Engines," SAE Transactions, March, 1940.
3. Tsien, H. C., "Basic Problems in the Design of High Output Aircraft Engines," presented before Metropolitan Sections. SAE. December 1. 1938.

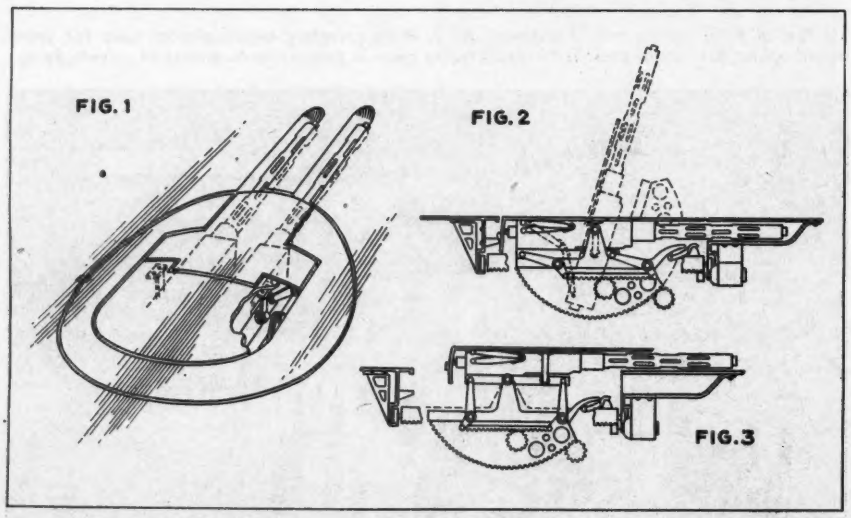
Review of Patents

By A. HARRY CROWELL, *Registered Patent Lawyer*

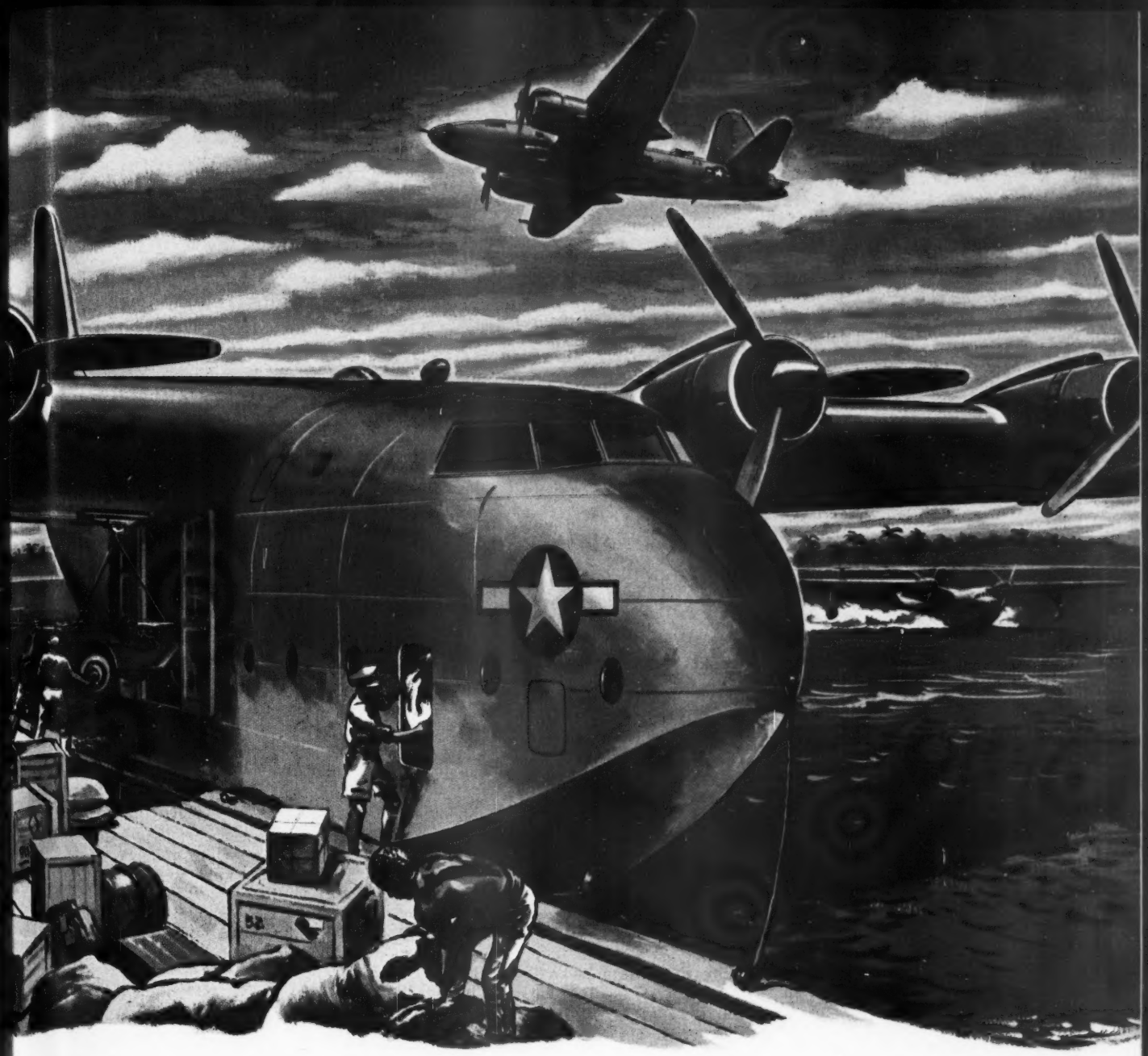
FOLLOWING are digests of some of the more interesting recent patents on aviation developments granted by the U. S. Patent Office. Mr. Crowell will gladly furnish readers with free information on approximate cost and procedure in applying for patents and trademark registration. Address inquiries to him, care AVIATION, 330 W. 42nd St., New York City (18). Printed copies of any of patents listed are obtainable at a cost of 10c. each, directly from U. S. Patent Office, Washington.

Retractable Undercarriage Development relates to systems where energy necessary for lowering landing gear is accumulated during immediate preceding lifting operation, especially where such energy accumulation is achieved, via hydropneumatic accumulator, through lifting jack. Called for is lowering operation effected in two periods, in such conditions that major part of driving energy available at accumulator is consumed in final period of lowering. And conversely, during lifting operation, major energy consumed in jack serves to raise pressure of accumulator, during first period, whereas during following period stress of jack is mainly used to overcome resistant stress of undercarriage. Patent particularly de-

(*Turn to page* 277)



Aim in design of new remote-control gun turret is least drag in airstream while retaining high maneuverability of weapons and large range of fire. In design form depicted above, turret lies fully flush with surrounding skin of aircraft structure when not in use; in another form it lies flush except for portions of gun barrels. Both arrangements feature minimum protrusion of weapons during firing. Fig. 1 shows partial perspective view of flush turret, with guns retracted in recesses. Fig. 2 is side elevation, partly in section, with solid lines depicting weapons in retracted flush position and dotted lines showing them at extreme firing elevation. Fig. 3 illustrates how guns, when at extremity of firing arc, operate close to ship's body with least drag factor. Turret may be remotely controlled about several of its axes, affording optimum ranges of fire.—2,336,557, filed July 30, 1942, patented Dec. 14, 1943, H. H. McCallister, assignor to Glenn L. Martin Co.



Greater warloads for the Mars

Two more passengers . . . another drum of 100 Octane . . . or nearly 1400 rounds of cal. 50 ammunition — this is the warload bonus provided by the 411 lb. lighter installation of Curtiss hollow steel blades on the Martin Mars.

This impressive reduction in complete installation weight is achieved notwithstanding the addition of the automatic propeller synchronizer and reverse thrust for greater surface maneuverability — both exclusive Curtiss féatures.

CURTISS ELECTRIC PROPELLERS

Curtiss-Wright Corporation, Propeller Division

8 MILES UP—THE *P-38* GETS FINGER-TIP CONTROL

No matter *how much speed* a fighter-pilot has *he must also have maneuverability*—be able to get in fast and get out quickly.

Now, even with the P-38's phenomenally increased speed, he can do just that. For Lockheed engineers, by installing aileron boosters actuated by the revolutionary Hycon "Stratopower" hydraulic pump, have given him "finger-tip control" over speed faster than sound. The application of these boosters, made practical for the first time, provides faster response of control surfaces, and as a result the Lockheed *Lightning* now outmaneuvers many single-engined ships—and fights higher than ever before in the thin air eight miles up.

To speed the day of Victory, we are using to the limit every facility at our command in the production of Hycon "Stratopower" pumps, and all of them are reserved for the planes of our armed forces.

LET'S ALL BACK THE ATTACK—BUY MORE WAR BONDS

And after the war—for peacetime

Because of its compactness and phenomenally high pressure, furnishing *variable volume up to 3000 pounds per square inch*, the Hycon "Stratopower" pump will do a great many hydraulic jobs *better*.

Today there are available other Hycon Pumps and Valves in the 3000-pound range for commercial applications to control or actuate machine tools, giant presses, dump truck lifts, materials-handling mechanisms and remote control circuits. They will operate brakes, clutches and steering devices of heavy vehicles; test high-pressure apparatus; and solve a wide variety of other hydraulic problems. For immediate delivery. Write for full information.

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Stratopower Pump

Manufactured only by The New York Air Brake Company

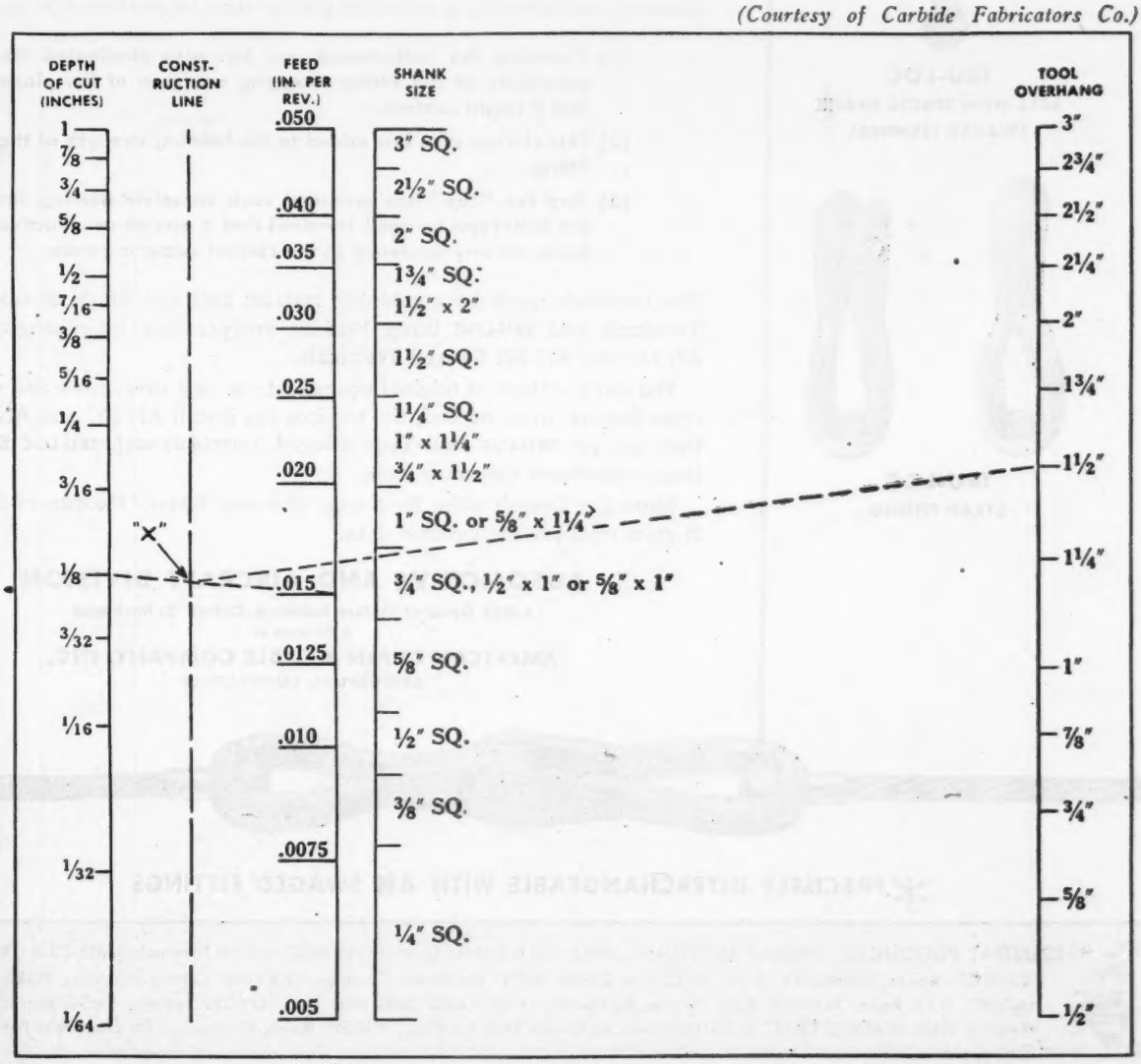
THE NEW YORK AIR BRAKE COMPANY
Hydraulic Division
420 LEXINGTON AVENUE, NEW YORK 17, N. Y.

SHEET NUMBER D-20
CLASSIFICATION . . . . . Production
SUBCLASSIFICATION . . . . . Carbide-Tip Tools

Shank Size Calculations For Carbide-Tipped Tools

LOAD ON TOOL TIP is determined by *feed* and *depth* of cut. Experiments show speed does not greatly affect load. *Overhang* must be known in order to calculate bending moment. Applying these three factors (see accompanying nomograph) will give us the shank size. For example: Assuming a feed of .015 in. with a depth of 1/8 in., and an overhang of 1½ in., lay a straightedge between the ⅛ on the depth-of-cut scale and .015 on feed scale. Mark point "X" where straightedge crosses construction line. Join "X" to 1½ on tool-overhang scale and read shank size where line crosses shank-size scale. Here, size would be ¾ in. sq., ½ in. or ⅝ in. x 1 in., as most convenient.

(Courtesy of Carbide Fabricators Co.)



Redesigned!

PROVED THROUGH SERVICE, TRU-LOC STRAP FITTINGS HAVE BEEN REDESIGNED BY EXPERIENCE*

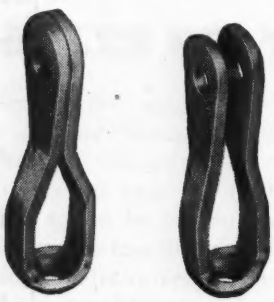
Streamlined may be the word to describe the advance made by redesigning the proved **TRU-LOC STRAP FITTING.** In fact, "cupping" the end that provides bearing for the Ball•Type Swaged Terminal and redesigning the opposite or "open" ends of the fitting have given streamlined appearance to the fitting. However, the advantages are much greater than improvement in appearance.

(1) Providing the ball-shaped cup has also eliminated the possibility of the fitting snagging any part of the plane that it might contact.

(2) This change also has added to the loading strength of the fitting.

(3) And the "cup" has provided such complete bearing for the Ball•Type Swaged Terminal that it acts as an effective brake on any tendency of the control cable to rotate.

TRU-LOC
BALL WITH SINGLE SHANK SWAGED TERMINAL



TRU-LOC
STRAP FITTING

The terminals made by combining **TRU-LOC** Ball and Single Shank Swaged Terminals and **TRU-LOC** Strap Fittings are precisely interchangeable with AN 667 and AN 668 Swaged Terminals.

You can use them as original equipment—saving time, labor and cost. For replacements, when needed, the services can install AN 667 and AN 668. Or they can use **TRU-LOC** Ball•Type Swaged Terminals with **TRU-LOC** Strap Fittings—whichever they may have.

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***PRECISELY INTERCHANGEABLE WITH AN SWAGED FITTINGS**

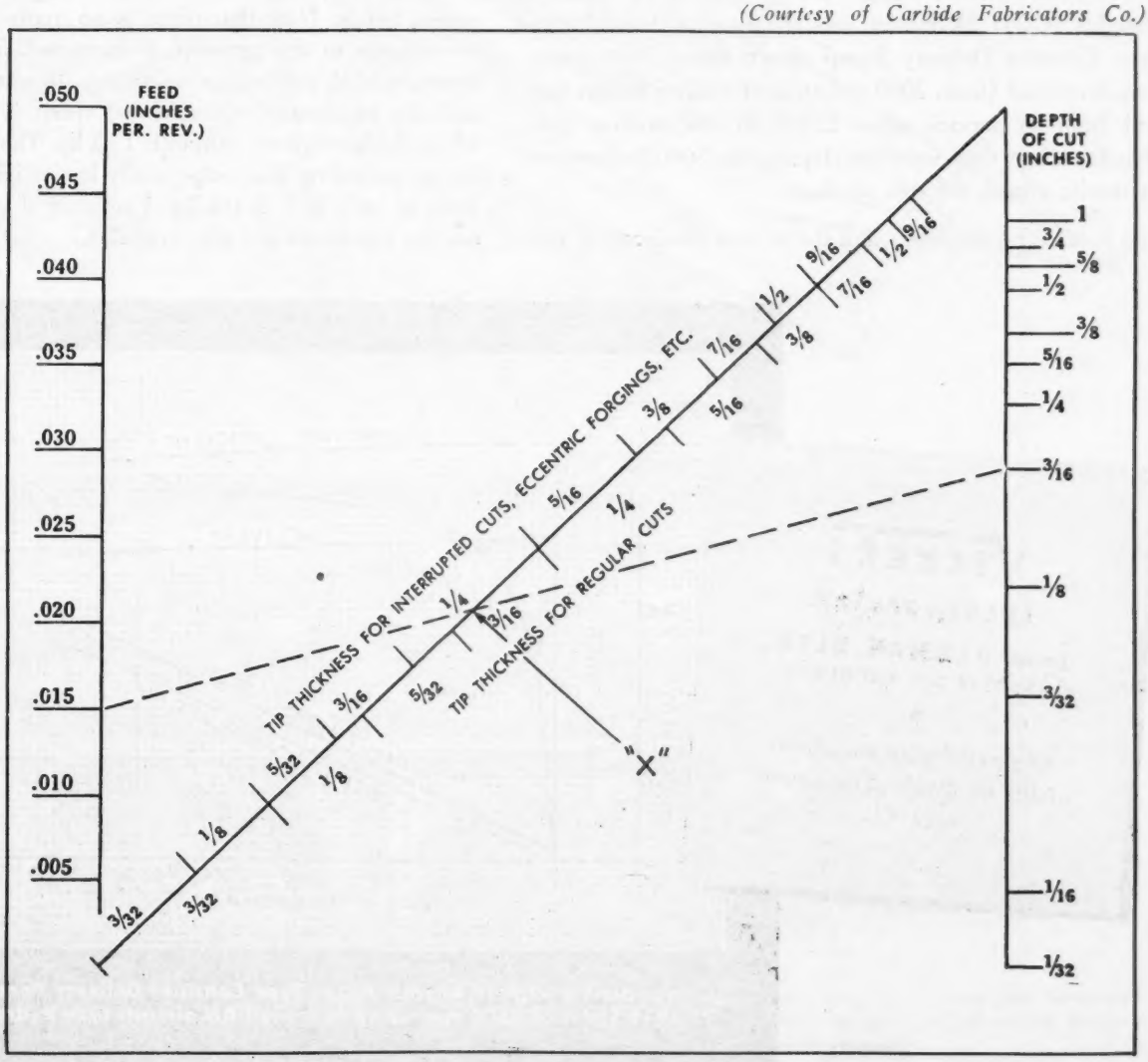
ESSENTIAL PRODUCTS...TRU-LAY Aircraft, Automotive, and Industrial Controls, TRU-LOC Aircraft Terminals, AMERICAN CABLE Wire Rope, TRU-STOP Brakes, AMERICAN Chain, WEED Tire Chains, ACCO Malleable Castings, CAMPBELL Cutting Machines, FORD Hoists, Trolleys, HAZARD Wire Rope, MANLEY Auto Service Equipment, MARYLAND Bolts and Nuts, OWEN Springs, PAGE Fence, Shaped Wire, Welding Wire, READING-PRATT & CADY Valves, READING Steel Castings, WRIGHT Hoists, Cranes . . . *In Business for Your Safety*

SHEET NUMBER . . . . . D-20 (Cont'd)
CLASSIFICATION . . . . . Production
SUBCLASSIFICATION . . . . . Carbide-Tip Tools

Tip Size Calculations For Carbide-Tipped Tools

TO USE THIS NOMOGRAPH, again decide on *feed* and *depth* of cut. Locate feed on scale at left-hand side in inches per rev. and depth of cut in inches on right-hand scale. Line connecting these points will show tip thickness where it crosses angular line in center of diagram. Example shows $\frac{3}{16}$-in. depth of cut and .015-in. feed per rev. Line crosses center scale at $\frac{3}{16}$-in. thickness for point for regular cut and ¼-in. for interrupted cut.

(Courtesy of Carbide Fabricators Co.)



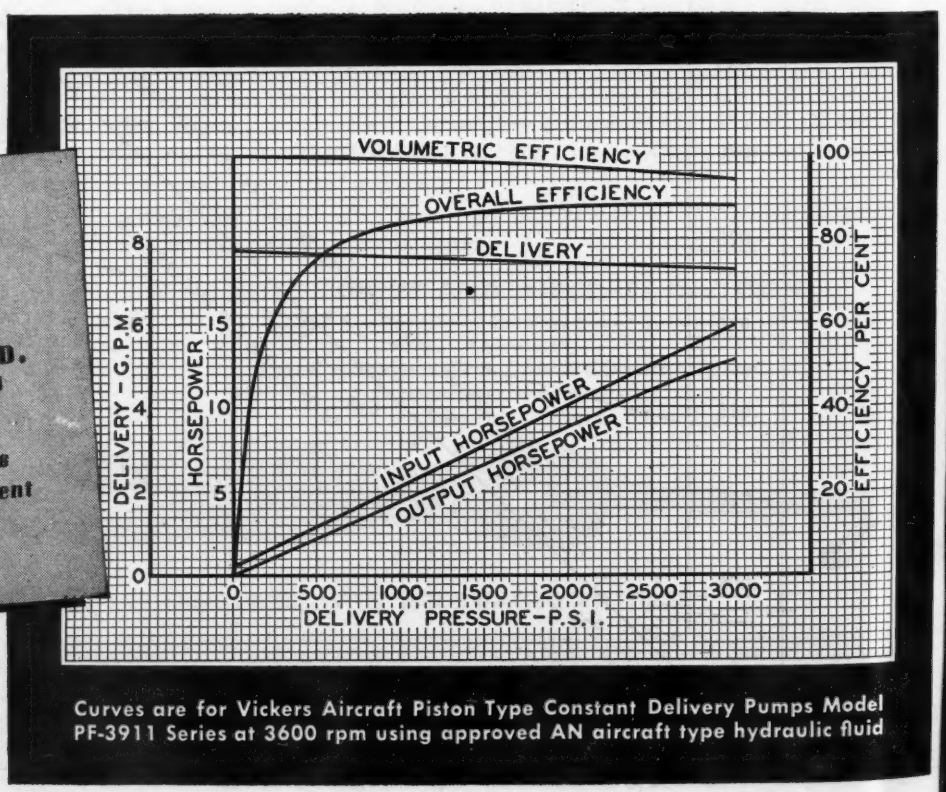
3000 psi Vickers piston type pump complies with Winterization Specifications of the Army Air Forces for operation between —65° F and 160° F.

CKERS PUMP *Used in* 3000 psi HYDRAULIC SYSTEM

ON DOUGLAS SKYMASTER (C-54)

It is significant that the 3000 psi hydraulic system on the Douglas (C-54) Skymaster uses the Vickers Axial Piston Type Constant Delivery Pump shown above. This pump was developed (from 2000 psi units of similar design that had been in service since 1935) in cooperation with Douglas when they were developing the 3000-lb pressure hydraulic system for this airplane.

The volumetric efficiency and the overall efficiency of this pump are very high . . . as indicated by the performance curves below. Note that there is no appreciable increase in slippage as the pressure is increased. The maximum recommended continuous operating pressure is 3000 psi and the maximum recommended speed is 3750 rpm at which the horsepower output is 13.3 hp. The weight is only 6.8 lb, providing the exceptionally low weight/horsepower ratio of only 0.51 lb per hp. Pumps of this series having smaller capacities are also available.



Curves are for Vickers Aircraft Piston Type Constant Delivery Pumps Model PF-3911 Series at 3600 rpm using approved AN aircraft type hydraulic fluid

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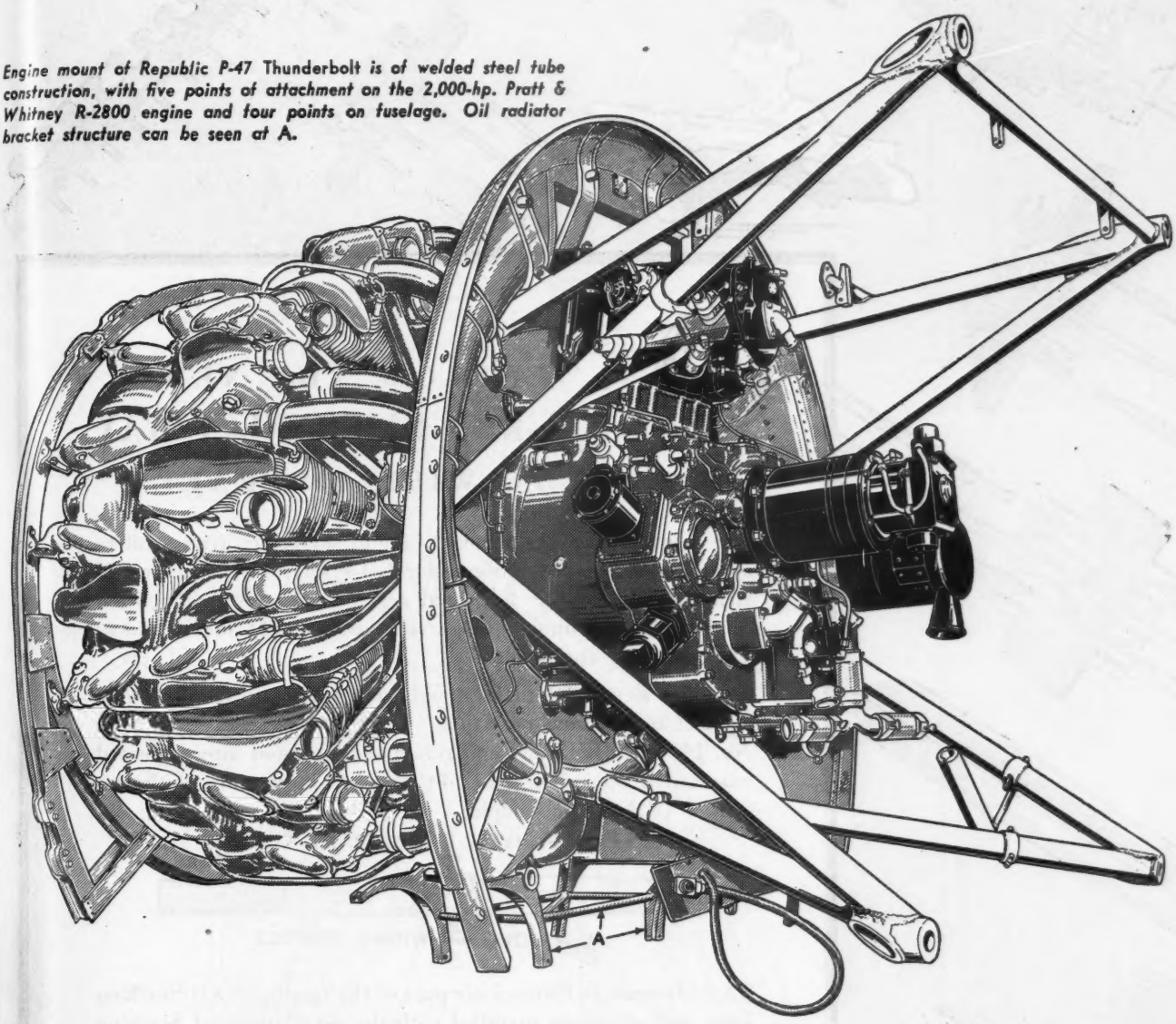
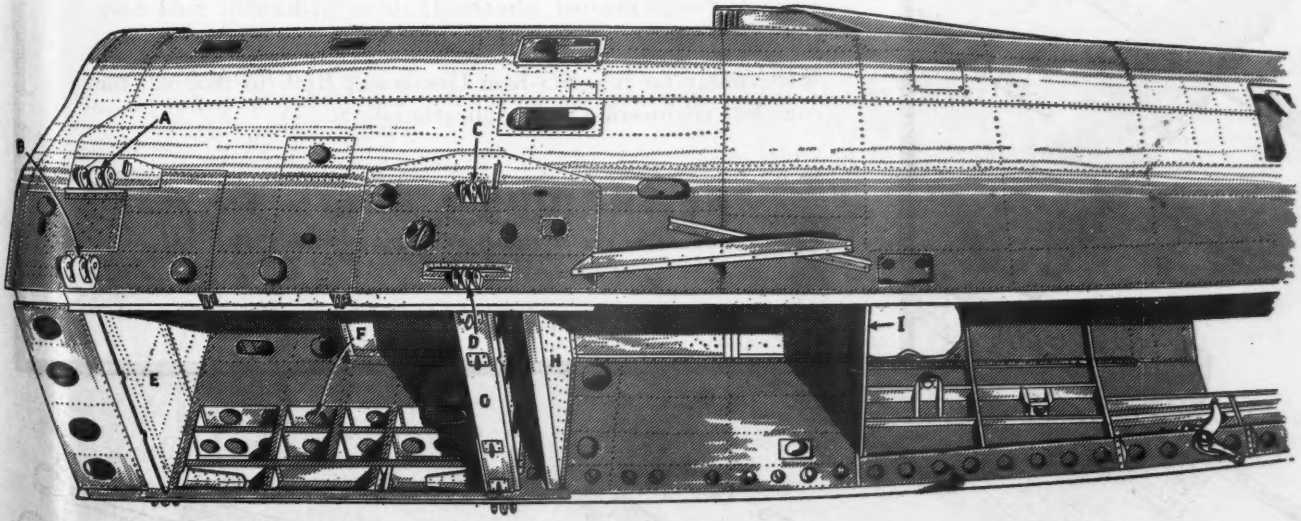
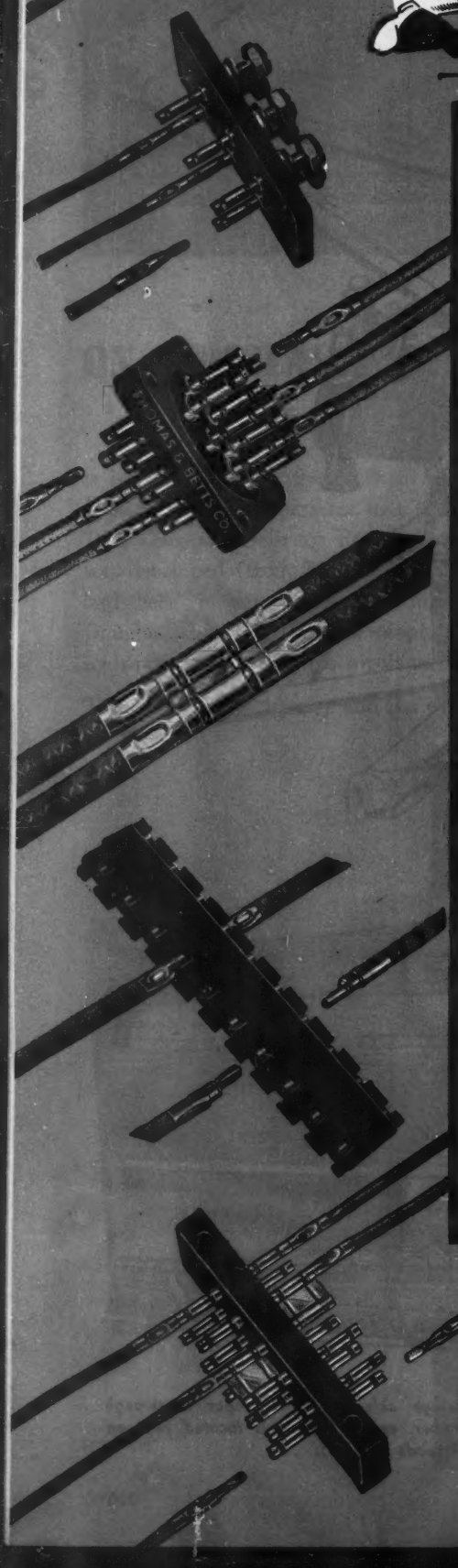
Engine mount of Republic P-47 Thunderbolt is of welded steel tube construction, with five points of attachment on the 2,000-hp. Pratt & Whitney R-2800 engine and four points on fuselage. Oil radiator bracket structure can be seen at A.





Main portion of P-47 fuselage is designed for construction in upper and lower sections. Seen from below, this view of upper portion shows four wing fittings A, B, C, and D. Firewall is attached to front spar tie-through E. Note built-up type structure at F forming fuselage side. G is rear-spar tie-through member, and fuel cell is located between bulkheads H and I.

stalled in Standard
AN Housing.

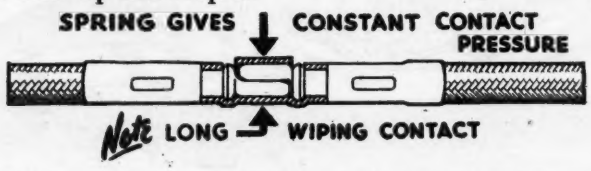


T&B

FOLLOW THE NEW STA-KON DISCONNECT WAY TO WIRE AIRCRAFT

The new Sta-Kon Disconnect* Line of solderless fittings offers almost endless combinations—for faster sectionalized wiring of airframe assemblies,—for rapid replacements at modification centers, for continuity of service and combat maintenance. They are fully approved.

These new T&B fittings make it possible to connect, disconnect and reconnect *at will* any electrical wires No. 22 through No. 10. They hold fast and retain their tension after repeated usage with no impairment to the locked-in-pressure of the essential T&B tip and coupler.



T&B Disconnect Fittings are part of the familiar T&B Sta-Kon Line, and are easily installed with the same standard Sta-Kon pressure tools—manual, electrical, air or hydraulic. Sold only through T&B Distributors.

Write today for new Sta-Kon Disconnect Bulletin No. 522 for complete engineering and application data.

THE THOMAS & BETTS CO.
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manufacturers of electrical fittings since 1899
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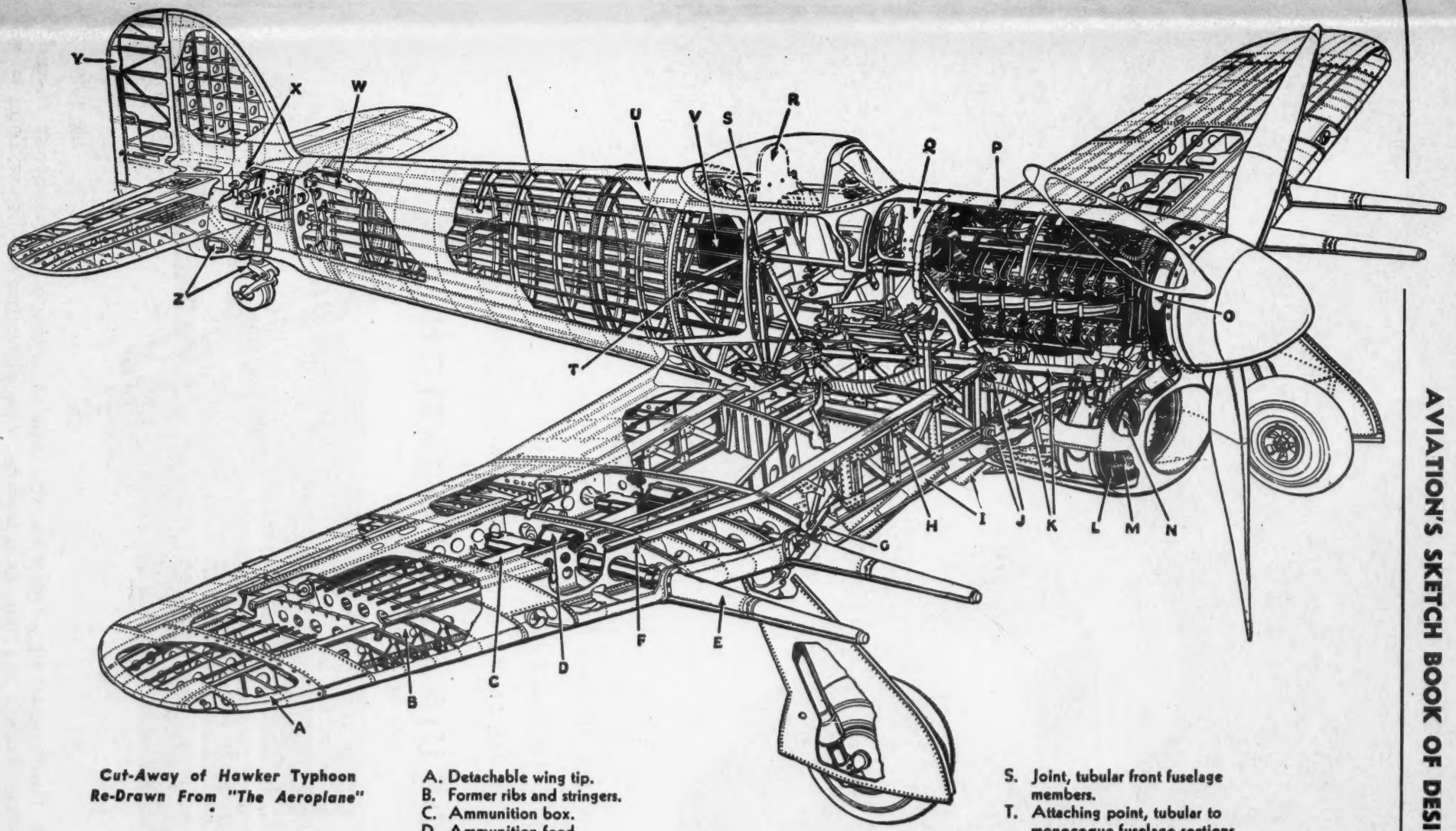
In Canada: Thomas & Betts Ltd. Montreal

*Patent pending· Sta-Kon Reg. U. S. Pat. Off.

AVIATION'S SKETCH BOOK OF DESIGN DETAIL



Cut-Away of Hawker Typhoon
Re-Drawn From "The Aeroplane"

A. Detachable wing tip.
B. Former ribs and stringers.
C. Ammunition box.
D. Ammunition feed.
E. 20-mm. cannon.
F. Front spar change section.
G. Landing gear side brace.
H. Landing gear retracting unit.
I. Landing gear fairing.
J. Front spar attaching points.
K. Engine mount.
L. Engine coolant radiator.
M. Oil radiator.
N. Supercharger air intake.
O. Coolant tank.
P. 2,200-hp. Napier *Sabre* engine.
Q. Oil tank.
R. Armor plate.
S. Joint, tubular front fuselage members.
T. Attaching point, tubular to monocoque fuselage sections.
U. Monocoque fuselage covering.
V. Radio.
W. Elevator mass balance.
X. Stabilizer attaching point.
Y. Fabric covered rudder.
Z. Retractable tail wheel and hydraulic piston.

AEROQUIP SELF SEALING COUPLINGS AND HOSE LINES
WITH DETACHABLE FITTINGS ARE STANDARD
ON ALL ARMY AND NAVY AIRCRAFT.

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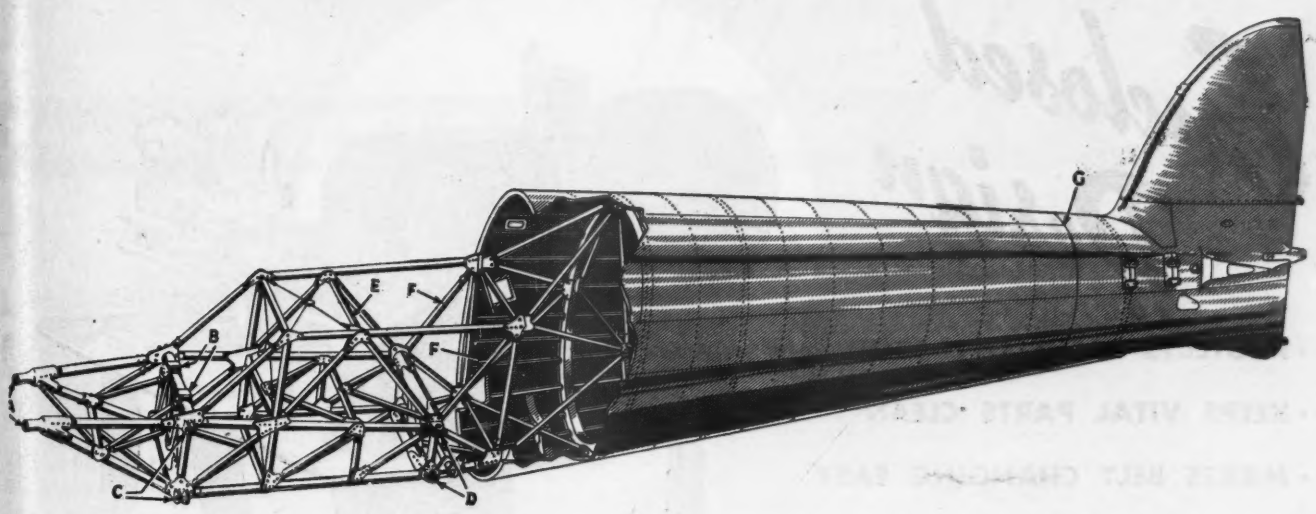
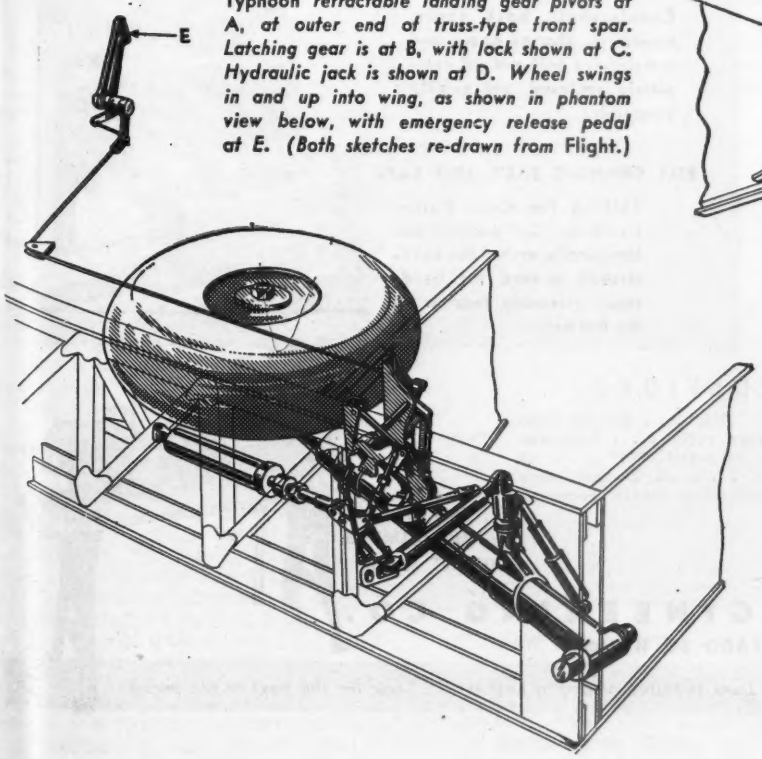
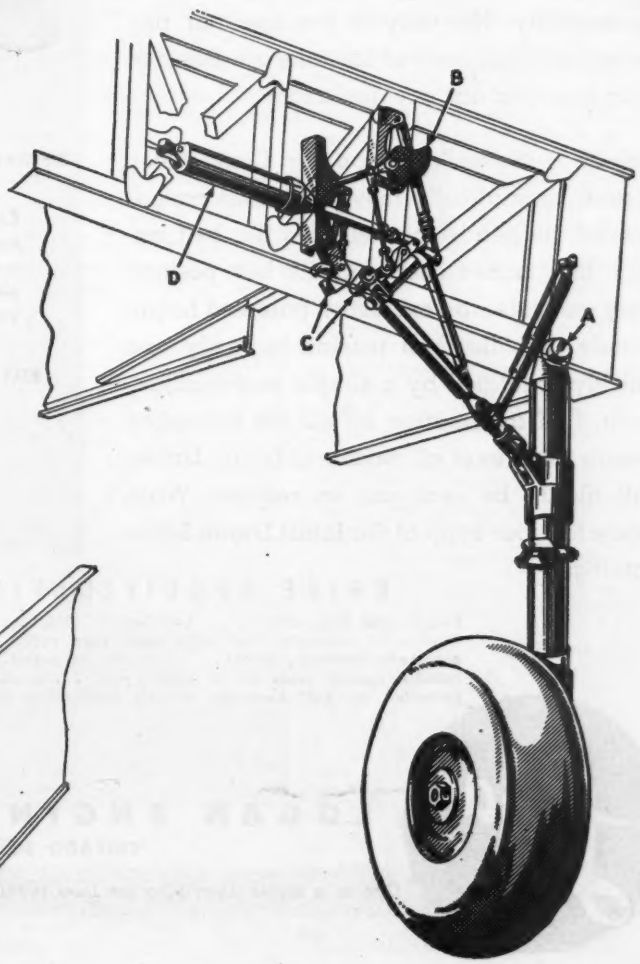
PERMANENT LICENSEE: WAGNER ELECTRIC CORPORATION, 6400 PLYMOUTH AVENUE, ST. LOUIS 14, MISSOURI



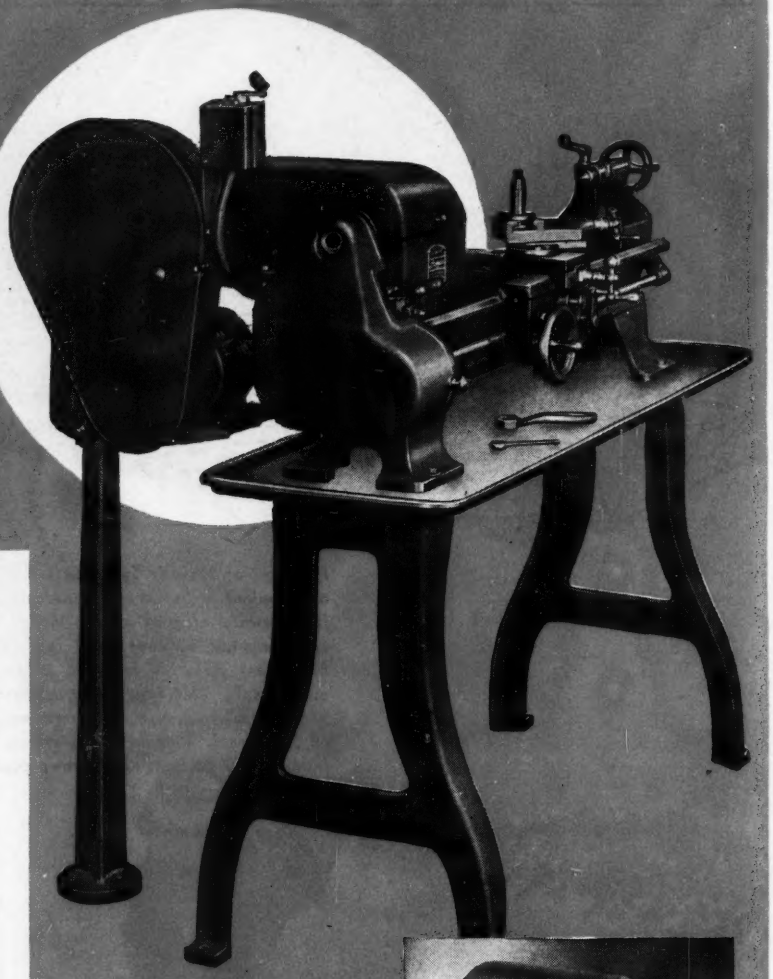
Fuselage of Hawker Typhoon I-B *is of combination girder and monocoque construction. Oil and coolant radiators and supercharger air intakes attach to forepart of girder structure at* A, *just forward of fore engine mount attaching point. Rear engine attaching points* B *are on cross member between front spar attaching points* C. *Rear spar attaching points are at* D. *Instrument panel is mounted atop cross member* E, *and pilot's seat is attached between members* F. *This type construction is used not only to absorb heavy stresses incident to a heavy plane but also to permit easier access for construction and maintenance. Aft portion of fuselage is built in two sections, joined together at* G, *with vertical fin built as integral part of rear portion. (Re-drawn courtesy of* Flight.)





Typhoon *retractable landing gear pivots at* A, *at outer end of truss-type front spar. Latching gear is at* B, *with lock shown at* C. *Hydraulic jack is shown at* D. *Wheel swings in and up into wing, as shown in phantom view below, with emergency release pedal at* E. *(Both sketches re-drawn from* Flight.)

Enclosed Design



- PROTECTS LATHE OPERATOR
- KEEPS VITAL PARTS CLEAN
- MAKES BELT CHANGING EASY

The operator does not catch fingers or clothing in moving belts or gears on a Logan Lathe. The Cone Pulley Guard in its normal "down" position completely covers the countershaft, headstock and back gear assemblies. The motor-drive belt and change gear assemblies are completely enclosed. All guards are quickly and easily opened giving complete accessibility. Not only is the operator protected, but vital parts of the lathe are shielded from dust and dirt accumulations.

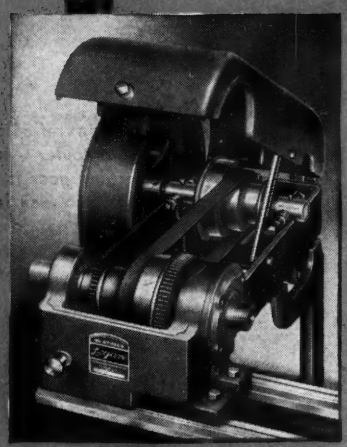
Raised to its "up" position, the Cone Pulley Guard automatically moves the countershaft toward the headstock, releases flat belt tension, and makes changing the belt position easy and safe...an exclusive, patented Logan feature. The flat belt tension is easily and quickly regulated by a simple screw adjustment. Full information on all the advanced design features of all models of Logan Lathes will gladly be sent you on request. Write today for your copy of the latest Logan Lathe catalogs.

OPERATOR PROTECTED . . . VITAL PARTS KEPT CLEAN

Countershaft, back gears, headstock, change gears and motor-drive belt are all completely enclosed, yet quickly accessible.

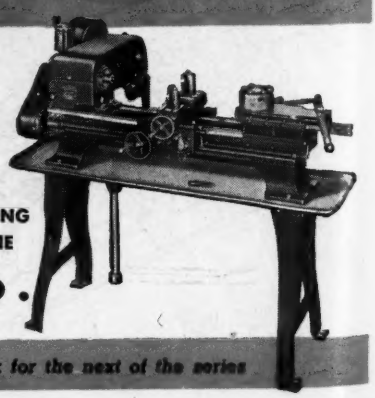
BELT CHANGES EASY AND SAFE

Raising the Cone Pulley Guard to "Up" position automatically moves the countershaft toward the headstock, releasing tension on the flat belt.



BRIEF SPECIFICATIONS

Swing over bed, 10½" . . . bed length, 43⅛" . . . spindle hole, $2\frac{5}{32}$" . . . capacity, ⅝" with push type collet . . . 6-position automatic indexing turret . . . stroke of turret, 4¼" . . . 12 spindle speeds from 30 to 1450 r.p.m. . . . all moving parts protected by ball bearings or self lubricating bronze bearings.



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The AVIATION NEWS

BLAINE STUBBLEFIELD, Washington HERB POWELL, New York

Launch Initial Postwar-Air-Policy Parleys; Peacetime Private-Plane Market Gaged

See few Army craft available or suitable . . . Johnston weighs market possibilities . . . SAE New York meeting . . . Chamber and NAA programs . . . JLC drafts air principles . . . CAB questions insurance rates.

Chief interest considered today by the airline industry is its place in the postwar foreign-service field. Will there be an open competition system, or will operators participate in a semi-official organization under just one management? Might there be a worldwide air council with, more or less, control over routes, schedules, rates? Will there be an international government subsidy race, or will the airlines pay their way on an economical basis? Will there be freedom of entry into various countries, or will landing rights be negotiated bilaterally? These and scores of other questions must be answered eventually by a United Nations Air Conference.

First steps toward such a conference have been taken. A U. S. air mission, headed by E. P. Warner, CAB vice-chairman, and Adolf Berle, chairman of the Special International Aviation Committee, has had exploratory talks in England and Canada. At this writing, another delegation, including L. Welch Pogue, CAB chairman, W. A. M. Burden, assistant Secretary of Commerce, and Mr. Berle, and headed by former Ambassador to Japan Grew, now special assistant to Secretary of State, Hull, was preparing for discussions with the Russians in Washington.

These meetings will lead to more conferences here and abroad during the summer. Many of the United Nations will participate, including China, Australia, and Canada. The secret report, written months ago by the special committee, formerly called the Interdepartmental Committee on International Aviation, has not been made public, but it becomes less important as new names and new information appear in the picture. Final word in this vital development may belong to the United States Senate, which has power of ratification of treaties. Senate foreign relations and commerce committees have been gathering data.

See Few Army Airplanes For Peacetime Flyers

How many Army artillery-liaison and Air Force training planes suitable for sale to private flyers will be for sale when the war ends is a matter of interested speculation by military and aircraft trade officials. They agree that the number will be small, perhaps a few hundred, not near enough to meet the initial postwar demand.

The liaison planes, most desirable for personal use, are largely overseas and many of them will not be returned. Air Force training planes are nearly all of the basic and advance types whose comparatively high horsepower takes more fuel than most private owners could afford.

Johnston Weighs Postwar Market Possibilities

That utility of light planes will remain limited for a while in the postwar period, and that total sales will not approach 20,000 per year for at least five years, even if there is general prosperity, is the opinion expressed by S. Paul Johnston, former editor of AVIATION and now Curtiss-Wright representative in Washington, in a book titled, *Wings After War*. Johnston believes it will take years to perfect the helicopter. Roadable light planes can be flown, but here high weight and cost will be hard problems. All-wing designs will not be practical in small sizes, that is, not much less than 300,000 lb. He does not feel that cargo gliders will be successful. His rough guess is that in new peace AAF will maintain about 18,000 planes and Navy about 10,000 in peacetime.

SAE New York Meeting Tackles Current Problems

SAE's recent National Aeronautical Meeting in New York City stressed problems which confront the engineer and manufacturer in today's war work.

The Wright Brothers Medal was presented at the dinner to C. E. Pappas, Republic Aviation Corp., for his paper "Determination of Fuselage Moments." SAE Pres. W. S. James spoke on "The Usefulness of SAE to the Aviation Industry," and Maj.-Gen. Frank O'D. Hunter, commanding general, 1st Air Force, told about "The Army Air Forces in the Present War."

During the three days, the following papers were presented:

"Measurement and Prediction of Aircraft Vibration," E. Forest Critchlow, CAA; "Engine Cooling Fan Theory & Practice," Kenneth Campbell, Wright Aero; "Aircraft Engines in Tanks," G. Waine Thomas, Continental Motors; "Trends in Ice Prevention," Lewis A. Robert, NACA; "Pneumatic De-Icer," J. E. Gulick, B. F. Goodrich; "Cold-Weather Operation of Aircraft," G. A. Bleyle, Wright Aero; "Propeller & Gear Ratio Requirements for Cruising Aircraft," R. S. Schairer, Douglas Aircraft; "Aircraft Maintenance in Combat Areas," Lt.-Comdr. R. E. White, USNR, (paper read by Lt.-Comdr. F. E. Johnson, USNR); "Fundamentals of Aircraft Design, A. L. Klein, Douglas Aircraft; "Basic Principles of Power Boost Flight Controls," E. G. Riley, Glenn L. Martin; "Stresses in Disk Wheels," William Knight, Curtiss-Wright; "Piston Ring Development for V-770 Engine," C. H. Van Hartesveldt and M. Epps, Ranger Aircraft Engines;

NEW ROTARY WING CRAFT

Kellett YO-60 autogiro, latest of line built for AAF, has added visibility made possible by bubble-type canopy and openings in floor, enhancing utility for reconnaissance, artillery spotting, and other observation work. Craft is powered by 300-hp. Jacobs engine.

Coming Up

May 1-3: Third Wartime Aviation Planning Conference. The A. & M. College of Texas, College Station, Tex. Also Aviation Writers Assn. annual convention.

May 18-20: Spring Meeting, Society for Experimental Stress Analysis, Hotel Statler, Boston, Mass.

October 5-7: Society of Automotive Engineers National Aircraft Engineering & Production Meeting. Engineering Display. Hotel Biltmore, Los Angeles, Calif.

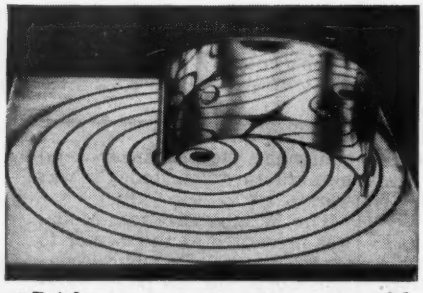
December 4-6: Society of Automotive Engineers National Air Cargo Meeting. Hotel Knickerbocker, Chicago, Ill.

January 8-12, 1945: Society of Automotive Engineers Annual Meeting & Engineering Display, Book-Cadillac, Detroit, Mich.

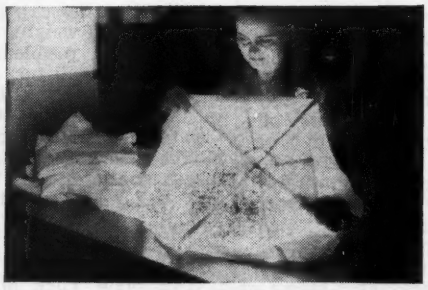
INSPECTION PROBLEMS?

Here's how Controlled Lighting saves time on tough inspection jobs

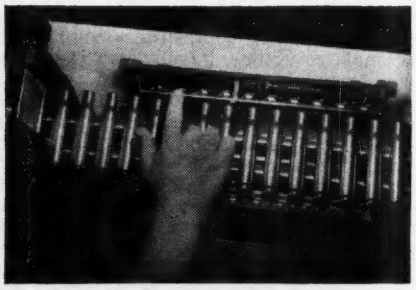
TO look inside a 75 mm. shell was difficult . . . until G-E lighting engineers helped work out a faster, more accurate inspection method. A standard G-E reflector lamp with a mirror arrangement "turns shells inside out"—makes sure there's no grease, dirt or pitting. It's a typical example of inspection methods that use controlled lighting . . . and it's another instance where G-E engineers have helped to gain faster, better inspection methods.



1 Brightness contrast patterns are useful for the inspection of chatter in polished metallic surfaces. Reflections reveal defects of unevenness and other irregularities.



2 Luminous panels permit accurate checking of cloth seams, weave and finish. Shown above, this type of inspection permits accurate examination of all seams in pilot parachute manufacture.



3 An inspection unit developed specifically for cartridge case inspection. It makes use of reflected light from mirrors, showing the interior and primer cup end of the cases.

In these special applications—or in standard lighting installations—be sure you get the utmost in dependability and operating efficiency. Look for the famous G-E monogram on all the bulbs you buy. It's your assurance of best results for every lighting purpose.

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The Creed of G-E LAMP RESEARCH

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LET'S ALL BACK THE ATTACK—BUY ANOTHER BOND THIS MONTH!

G-E MAZDA LAMPS

GENERAL ELECTRIC

Hear the General Electric radio programs: "The G-E All-Girl Orchestra" Sunday 10 p. m. EWT, NBC; "The World Today" news, every weekday, 6:45 p. m. EWT, CBS.

"Aerodynamics of Cooling Ducts," K. F. Rubert, NACA.; "Relation of Intake Charge Cooling to Engine Performance," E. A. Droegmueller and D. S. Hersey, P & W; and W. A. Kuhrt, Research, United Aircraft; "The Intercooling Problem in Airplane Design," H. B. Dickinson, Lockheed; "Particulars of the German V.D.M. Electric Propeller," John D. Waugh, Lockheed Overseas; "Propeller Efficiency of a Light Airplane," K. D. Wood, Purdue Univ. and W. R. Woodward, Bell Aircraft; "Engine Production as Viewed by an Automobile Manufacturer," Col. J. G. Vincent, Packard Motor Car; "Investigation of Chafing of Engine Parts," H. C. Gray and R. W. Jenny, Wright Aeronautical; "Hydraulic Engine Power Controls," Howard Alexanderson, Eclipse-Pioneer; "Pre-Rotation of Landing Gear Wheels," H. F. Schippel, B. F. Goodrich; "Design for Production of Sheet Metal Aircraft Parts," F. M. Mallet, Curtiss-Wright; and "Analysis of Airframe Production Methods in Aircraft and Automobile Industries," Thomas N. Kelly, Consolidated Vultee.

Highlights of Aero Chamber And NAA Programs

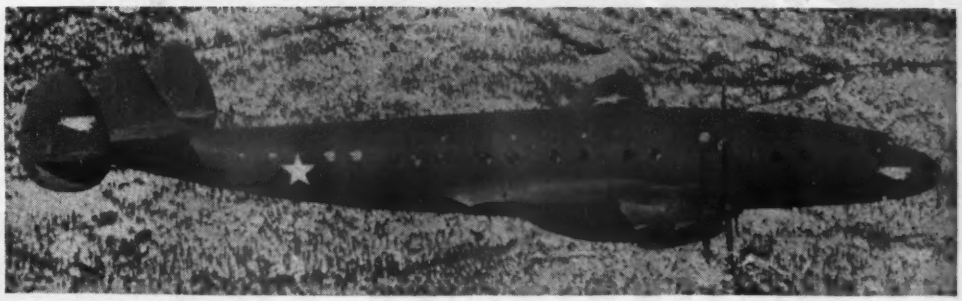
Construction of thousands of landing areas throughout the country, less bothersome regulation on personal flying, and practical education of the public in the utility of light airplanes are major policies of the Personal Aircraft Committee of the Aero Chamber of Commerce. Small cities and towns are asked to build modest airports for convenience, not expensive ones for showoff. The small-field program, if started now, will advance airmindedness and the sale of personal planes, the committee believes. Many homecoming service airmen and women would like to go into the airfield and service business. The committee also is urging the CAB to modify the difficulties of getting airplane type certificates.

The NAA has established a postwar policy intended to aid the increase of private flying by supporting a suitable airport program, by encouraging the study of aviation in schools, and working with manufacturers for the design of better airplanes. It advocates private ownership of airlines as opposed to any government ownership that might be proposed, also seeks the establishment of a Department of National Defense, combining Army, Navy, and Air Forces. NAA will work with any and all organizations having these objectives.

OBITUARY

Col. Lucius B. Manning died last month in a plane crash in Alabama. He was formerly a vice-president of American Airlines and a director of Consolidated Aircraft. An Airman in World War I, he was identified in 1932 with Cord Corp. airplane interests, later became head of American Airways, then a director of The Aviation Corp. Among other posts he held was the presidency of the Stinson Aircraft Co.

Inglis M. Uppercu recently died at his home in New York City. In World War I days, he operated a passenger airline connecting Miami, Nassau, Cuba, and Key West. He was, through the years, president of several companies which made planes at Keyport, N. J., one of these organizations being the Aeromarine Klemm Corp., manufacturer of light planes following a German design. Uppercu also organized the Uppercu-Burnelli Aircraft Corp. to promote the airfoil-body type craft of Vincent Burnelli.



"CONNIE" SETS RECORD

Flying TWA colors, Lockheed "Constellation" set speed record of better than 355 mph. in non-stop jump from Burbank to Washington's National Airport, actual coast-to-coast time being 6 hr. 55 min. Piloted by Howard Hughes and Jack Frye, TWA president, crew included Howard Bolton, navigator; R. I. Proctor, flight engineer; and C. E. Glover, radio operator. Craft is powered by four 2,200-hp. Wright "Cyclone 18's." Its Army designation is C-69. Sleeping accommodations for 38 are called for in airline version.

CAB Questions Insurance Rates

A study of aviation insurance and re-insurance, published by the CAB, suggests that the rates are too high and that important economic and military information is being piped abroad. It probably will result in reduction of rates by the three groups dominant in the field.

Nobody seems to want passage of the Lea bill, which would authorize the CAB to provide aviation insurance. Chances are that companies now serving the industry, or others, will find a way to handle re-insurance risk pooling in this country rather than dealing it out to British brokers.

JLC Drafts Air Principles

The principles which eight American aviation groups—comprising the Civil Aviation Joint Legislative Committee—believe should be incorporated in legislation now under consideration by Congress have been drafted and referred to the Aeronautical Law Committee of the American Bar Association.

Covered are provisions dealing with the questions of airports, air contractors, government training, powers of the administrator, taxation, safety, and insurance. The eight groups: Aero Chamber of Commerce, American Assn. of Airport Executives, Aviation Distributors & Manufacturers Assn., Early Birds, insurance groups, National Aeronautics Assn., National Assn. of State Aviation Officials, and National Aviation Trades Assn.

Produces Steel-Strong Alloy

Word comes from the Reynolds Metal Co. regarding its development of R-301, a new aluminum alloy stated to be as tough as structural steel but so light that its use in airplane will reduce weights by thousands of pounds, enabling carriage of more bombs and guns or design for increased speeds.

It has been reported that R-301 may even be employed in armor plate, Pres. R. S. Reynolds declaring that it is more effective in deflecting bullets than is steel plate. Thus far, the new alloy is being used solely for war purposes, but peacetime applications of it are being ranged.

Notes on Training Cut-Back

Civilian school aid to the Air Forces is being rapidly cut down because air crew manpower in training process is almost large enough to finish the war. CAA's War Training Service has stopped its Navy cadet and Enlisted Reserve instructor courses, and the 10-hr. air crew course is being tapered off. Eleven of the Army's primary schools, contracted directly with members of the Aeronautical Training Society, are being closed this summer. Six had already closed. Unless some provision is made for their continuance, all 64 will be shut down before the end of the war. AAF no longer gives primary training within its own military schools.

WASP Need Investigated

The Civil Service Committee of the House was, at this writing, inquiring into the need for the Women's Airforce Service Pilots (WASP). A bill had been introduced providing for the transfer of the WASPs from civilian status to eligibility for appointment to the AAF. Gen. H. H. Arnold, AAF chief, testified in favor.

Numerous complaints charged that hundreds of experienced male pilots are available for flying now done by the women, further contended that more men will be unemployed as WTS and Army contract schools are progressively closed. Navy and commercial airlines have refused to employ female pilots.

Finish 26 Flight Strips

Twenty-six flight strips have been completed by the Bureau of Public Roads for the AAF at various places throughout the country, with an appropriation of $10,000,000. Thomas H. MacDonald, Commissioner of Public Roads, recommends further study and continuance of the program for personal flying. A controversy is developing on the question whether single runways are practical. Most officials of CAA are favoring instead numerous small airports close to towns, country clubs, sports centers, and factories—places where people gather in large numbers.

★ SPOT CHECKING ★

Continental Air Lines' Denver modification center handled over 1,600 planes between July 1942 and Dec. 1943. Bulk of craft were Boeing B-17's, but center also handled two special jobs; one was for British, other was on North American P-51's.

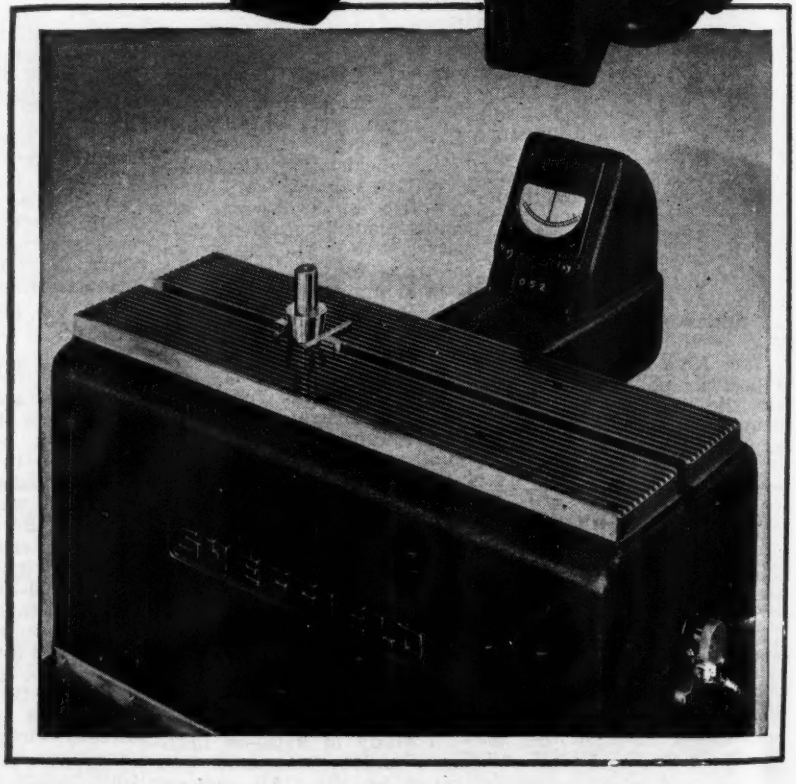
Aero Chamber survey shows 27.4 percent of aircraft engine engineers are under 26 yr. of age, exclusive of 4-F's. Total of 68.6 percent of the engineers are subject to draft.

Riddle Aeronautical Institute's Carlstrom field gave primary flight training to 5,251 cadets during past three years, with flying total of 402,774 hr. and 36,249,660 mi.

A $2,000,000 AAF storage depot, scheduled for completion in December, is under construction on 185-acre site of old San Francisco Airdrome in Ala-

Checks

To MILLIONTHS of an Inch



UNUSUAL FEATURES FACILITATE FAST AND ACCURATE OPERATION

Model N-4 Internal-External Measuring Instrument is an entirely new Sheffield development for Toolroom and Gage Laboratory use in checking master and working gages, setting snap gages, etc.

- Checks internal dias. of ¼" to 12".
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- Gaging arms elevated electrically.
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meda, Cal. Depot will provide five warehouses to store new supplies and used material from overseas awaiting repair.

North American's P-51 "Mustang" is officially credited by War Department with being world's fastest airplane, capable of level flight "in excess of 425 mph." with tactical radius "well over 500 mi." British had previously advertised de-Havilland "Mosquito" as being "world's fastest operational" craft.

SEC report shows aircraft industry's 1942 profits after taxes were 2.6 percent—compared with 3.5 for rubber, 3.6 for rail equipment, 4.1 for electrical equipment, 5.3 for industrial machinery, and 6.1 for agricultural machinery.

Newest speed record from Hawaii to American mainland is 8 hr. 55 min. It was set by a Consairways "Liberator" transport completing its 55th round trip to Australia. Average speed for 2,400-mi. hop was 269 mph.

Sales of excess inventories by five Eastern aircraft producers topped $1,320,000 in 748 deals in first of two weeks' disposal program.

CAA engineers are reported to have designed a $700 plane—including engine—which could be built by high school students. Model, however, has not yet been certificated by CAB.

Franklin Institute's John Price Wetherill Medal has been awarded this year to the late Richard C. duPont. The posthumous honor cited "his development of a successful and practical 'on-the-wing' airmail and glider pickup appartus."

Eight squadrons of PB4Y's, Navy adaptation of *Liberator* for over-water patrol, have been activated. Deliveries of Navy's sub-socking model of North American B-25 *Mitchell*, are increasing.

A Boeing report on the use of cameras shows that clouds form as high as 35,000 ft., a fact some scientists have not realized. Tests have shown temperatures of 106 deg. below zero at 40,000 ft. B-17's have been going to 42,000 ft., which is said to be a record for their weight and power.

TRY TO FIND ONE, BUB

Nazi fighter pilot demonstrates to Jerry novices the method of trying to find blind spot on Consolidated B-24 "Liberator." Wire frames on model held aloft show fields of fire covered by "Lib's" 50-cal. machine guns. Latest models would require even more wire frames. (International News photo from neutral sources.)

New general consulting research,, and survey service for the aviation industry was recently formed under the name Aviation Associates. Director is V. C. Rasmussen, who has had 10 yr. experience in airline traffic, in operations, publicity, financing, and insurance. D. H. Colcord is in charge of postwar sales engineering, and consultants are V. J. Sweeney and G. R. Higgins. Main office is at 664 N. Michigan Ave., Chicago (11), Ill.

Representatives of five Eastern aircraft firms recently organized the National Society of Plastic Tooling. President is Delmar Anderson, superintendent, production planning and tool design for the Buffalo plants of Curtiss-Wright. Besides Curtiss-Wright, other companies partaking are Bell, Consolidated Vultee (Allentown, Pa.), Grumman, and Glenn L. Martin. Information regarding the new group, which plans to expand west, will be sent to interested parties, who should address Harry W. Tompkins, Public & Internal Relations, Buffalo (5), N. Y.

Today, preservation and packaging of aircraft spare parts is pretty well standardized. If part is of non-corrosive material, it is packaged in specially developed waterproof outer carton. Parts that have machined ferrous surfaces are cleaned and treated with special compounds, then wrapped and packed in water-resistant shipping containers. Some containers can withstand several days total immersion. Sometimes in beaching operations supplies have to be dumped in water, and jungle conditions are often equivalent to immersion. Credited for development: Joint Army & Navy Working Committee, which was assisted by Aero Chamber's technical department.

A multi-purpose quilt has been developed by Wright Field for safety of flyers. Made of water-repellent material and chicken feathers and weighing only 2-4/5 lb., it gives warmth and has enough buoyancy to sustain a man in water indefinitely. Moreover, tie-straps enable it to be set up as pup tent or hammock, and it makes cozy sleeping bag, a slit in the center further enabling wearer to use it poncho style. Olive drab on one side, brilliant yellow on other, it can be used in signaling. The waterproof, non-toxic carrying case can be used for storing water.

Over 50 AAF bombers have returned to their bases on electronic autopilots .though control cables had been shot away, according to Minneapolis-Honeywell Regulator Co., co-makers of the unit.

CAA researchers report that the flying illness hyperventilation—commonly called 'huff and puff"—can be easily cured despite its long name. The resulting dizziness, tingling of fingers and toes, or feeling of suffocation may be voluntarily curbed by one's slowing breathing or inhaling and exhaling several times into a paper sack. Hyperventilation is caused by overly-fast breathing, which supplies the lungs with too much oxygen, displacing needed carbon dioxide.

Three aircraft units—Convair of San Diego and two Fairchild Hagerstown plants—are among winners of Office of Civilian Defense's National Security Awards for superior achievement in plant security against explosions, fires, and other hazards.

WPB has restricted manufacture of aircraft lighting equipment to products certified by the Aeronautical Board or by the AAF, Navy Bureau of Aeronautics, or CAA in event of AB's lack of jurisdiction. Restriction also applies to installation. Aim is maximum interchangeability of parts, reduction of replacement delays in field, and savings of materials and manpower. Total '43 output value of the nearly 50 lighting equipment makers and several hundred subcontractors was $30,000,000, 15 times '41 value.

American Society of Tool Engineers' annual two-day meeting was underway in Philadelphia recently. Special feature was presentation in one session of series of papers dealing with engineering, production planning, tooling, actual foundry and machining production, inspection methods, etc., of a single vital war product, thus graphically integrating all problems.

THE WASHINGTON WINDSOCK

By BLAINE STUBBLEFIELD

What air attack has done to enemy ships, factories, surface transportation, oil fields, water supplies, and other installations can be measured more or less accurately. But how much more strength and damage the enemy might have turned upon us except for such Allied air attack cannot be precisely known until the information comes out of conquered Germany and Japan.

Mention of the B-26 at the front occurs with continued frequency in the press. A checkup reveals that there has been no curtailment in production of this plane, though the Truman Committee said there would be. True, in one of the two plants where it is built, monthly output has decreased. But that was to make way for another airplane which has priority over everything.

Our latest Stubblefield award goes to the Junior Chamber of Commerce of Wichita, Kan., for publishing a map showing the home town as the center of a big system of postwar global airlines.

Don't be over-impressed about the 6-ton bombs—or maybe it's 10-ton bombs by now. The experts are debating whether the same weight in smaller ones isn't better. And don't over-gage that word 'block buster.' In England, which gave us the term, a block is merely a unit or group of one or more flats.

Public reaction to fatalities among pilots training in this country is much more severe than it is to fatalities in air combat. Accordingly, training commands here at home are strongly tempted to stick by a comparatively safe regime. But trainees not experienced on the borderlines of safety are in more danger of operational accidents at the front. And this leads to washouts of more-expensive equipment—and of themselves.

A plan for bombing Japan was suggested the other day by a blond lady in a rose dress, standing by the cocktail bar. She said we should send up a formation, just the size and shape of flowery Nippon and when it was in place like a half sole, all bombs should be let go at once. Everything would be destroyed, the land would be plowed up—and fertilized with dead Jappos, ready to start farming. Wonder if the War Department is listening.

Remodeled B-17 Fortresses still armed with guns have been put to transport jobs by 5th Air Force in the Southwest Pacific.

To test falling characteristics of bombs, which sometimes drop at 500 mph., Air Services Ordnance Dept. has built a 700 mph. wind tunnel in Boston, in anticipation of still faster falls.

North American's P-51 "Mustang" is now giving the Nips hell as well as the Nazis, the War Department discloses. It is revealed that this craft's operation against the Japs dates back to early January.

Air Forces men have been paid on time—even under dive bombing attacks—by a "flying banking service" operating along front lines. Millions in pay comes home every month through free Army Personal Transmission Accounts.

Past, present, and future are covered in three recent booklets: Development of Wright Aeronautical Corp. is recorded in a

short, illustrated history. "A Guide to Postwar Product Development," third in a series by the NAM, outlines suggested solutions for some major problems. And "What Your Town Needs for the Coming Air Age," by Wm. T. Piper, president of Piper Aircraft, is a very thought-provoking job on airport planning for average American towns—full of good practical ideas.

A five-part questionnaire is being mailed to flyers throughout the country by Zimmer-Thomson's Aircraft Specialties Div. to determine postwar market for a low-cost automatic constant-speed propeller, such as company has developed for light and medium-powered aircraft. Final query asks about flyers' future airplane ownership plans.

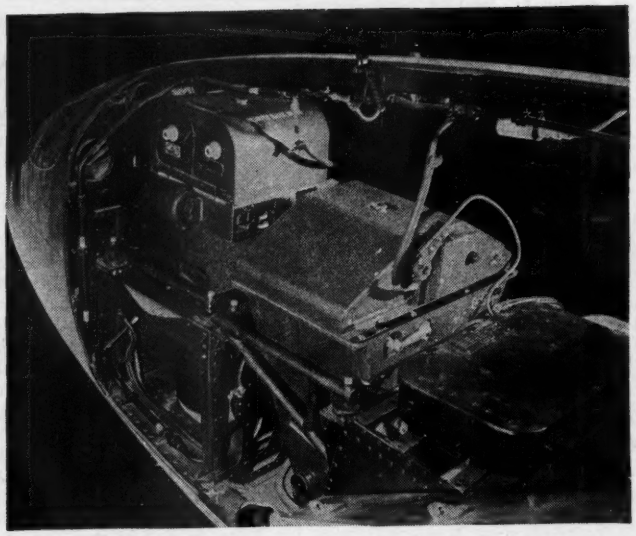
Construction proceeds on Lockheed's new $3,500,000 modification and rework base for Navy aircraft, to be known as Navy Lockheed Service Center. Location is adjacent to an airport near main company plants in Burbank, Calif. Personnel of 1,500 is planned.

Lastminutelines: The House's new Special Committee on Postwar Military Policy has listed on its agenda consideration of air bases and of means for their postwar maintenance . . . Geoffrey Smith, British jet propulsion authority is visiting the U. S. . . . Chrysler's huge Dodge Chicago plant, termed the largest aircraft engine factory in the world, is now in production (Wright 2,200 hp. plants) . . . James V. Forrestal, Under-Secretary of the Navy, states the Navy will get 28,000 combat planes in '44 . . . Brig. Gen. Samuel E. Anderson (he organized medium-level bombing attacks in European theater) has been appointed commander of the U. S. 9th Air Force Bomber Command, and Brig. Gen. Elwood R. Quesada now heads the 9th's Fighter Command. . . . It's now learned that during the invasion of Africa three L-4 Piper "Cubs" took off from carrier "Ranger" and landed on territory captured by the Allies.

★ CALLING NAMES ★

H. Russell Amory and **Wallace Mackenzie** have been chosen to head newly created executive staff of Aircraft Parts Manufacturers Association, Los Angeles. Amory will be general manager and Mackenzie head of business service section, replacing **C. C. Codding,** who resigned as association manager. **A. J. Brechtel** has been named to direct industrial relations. Amory was formerly with American Chamber of Commerce in London, England; Mackenzie was with Lockheed Aircraft Corp.; and Brechtel was with Plomb Tool Co., Los Angeles.

L. M. Bach is now general works manager in charge of manufacturing operations of all Lockheed A and B plants. He will be assisted by **D. J. Haughton,** asst. gen. works mgr., and **G. H. Prudden** (plant A) and **Penn Holter** (plant B) works managers. **E. Stackhouse** was named director of manufacturing development; **W. G. Dollmayer,** asst. works mgr. at plant A; and **B. W. Loyd** and **M. E. Mauer,** new asst. directors of manufacturing development. **Roger Lewis** is new director of purchases and **E. A. Brown** heads office of material control. Both report to **H. E. Ryker,** vice-pres. in charge of material control, and to **B. W. deGuichard,** now asst. to Ryker. **Walter G. Hoskinson** is new director of inspection for both A and B plants and is assisted by **Ralph M. Willis** and **Dale E. Hixson** as chief inspectors at plants A and B, respectively.



LOCKHEED F-5's "FIREPOWER"

First photo released showing camera installation in nose of Lockheed F-5 photo-reconnaissance version of "Lightning." Wide variety of installations are used, with cameras having lens running from 6 to 40 in., operated singly or as group. Latest device is shutterless continuous-strip camera in which film winds past narrow slit, its speed synchronized with speed and altitude of plane. F-5's "shoot" enemy installations from roof-top to substratosphere levels. Unarmed, "Focus Cat" pilots rely on high speed and maneuverability to evade enemy fighters and flak, saving of 400 lb. weight having upped craft's velocity as well as range.

Robert M. Boehm was incorrectly referred to as director of research for Grumman in article titled, "Masonite Dies Do A-1 Job" (page 142, Mar. **Aviation**). Actually he is director of research for Masonite Corp., Laurel, Miss.

Henry (Hal) Kerr is appointed to handle aircraft sales engineering activities for Hayes Industries.

Russell H. Potter is appointed national promotion manager for American Airlines.

Donald A. Sutherland was named field engineer in charge of sales and promotion activities for McCulloch Engineering.

Phil I. Harr, Fairchild service manager from 1936 to 1941 and production planning manager from 1941 to 1944, has been placed in charge of newly established quality control department at Hagerstown.

Lt. Comdr. Joseph W. Antonides, USN, is new Bureau of Aeronautics representative of Consolidated Vultee's Allentown Div., succeeding **Lt. Comdr. Harry Vought, Jr.,** USNR, now detailed to Edo Aircraft Corp.

Louis C. Boochever, Hill & Knowlton public relations representative, is assigned as resident director of Consolidated Vultee's Allentown Div.

At Hamilton Standard, **Sigmund A. Czarnecki,** chief equipment engineer, becomes staff asst. to factory manager, and **Park D. Ritchey** succeeds him as chief equipment engineer.

Darwin J. Adams joins public relations department of Interstate Aircraft & Engineering Corp. He was founder and original editor of **Sportsman Pilot,** co-organizer of Aviation Country Clubs, and at one time president of Aviation Advancement Corp.

John D. MacArthur is appointed district traffic manager for Continental Air Lines, replacing **Seale E. Fuller,** now in armed services.

Ray Collins heads new aviation division of Automotive & Aviation Parts Manufacturers.

John P. Bernard is now vice president and general manager of Sheffield Corp.

John L. "Jack" Carson, N. W. Ayer & Son public relations man handling Boeing Aircraft, leaves to become lieutenant (jg) in the Navy's amphibious command. He will be succeeded by **Bill Roller.**

Juan T. Trippe, Pan American president, and **Evan E. Young,** vice-president, were decorated with Heraldric Order of Christopher Columbus, bestowed by **Gen. Rafael L. Trujillo Molina,** President, Dominican Republic, in recognition of their friendship for country and meritorious services to it through the airline.

Col. **Roy W. Leggett** has been appointed chief of staff (he formerly was acting chief) to **Maj. Gen. John F. Curry,** commanding general of AAF Western Technical Training Command.

William H. Dayton, asst. western district supervisor, AAF, has been promoted to full colonel.

William Diltz, supervisor at UAL's Cheyenne modification center, was presented with a $500 War Bond for his suggestion which saved the line 20,000 man-hours annually.

Dr. Harry L. Andrews is now coordinator of training for Penn-Central.

C. C. West, Jr., on military leave from Continental Air Lines, was promoted to lieutenant colonel ATC.

Jerome Lederer joins Aero Insurance Underwriters as asst. manager; **Fred N. Davey** becomes asst. manager charge of production; and **Donald M. Stewart,** asst. manager charge of underwriting for the company.

Jacob Jacobsen, Boeing Aircraft employee, recently celebrated his 25th year with company.

N. F. Vanderlipp, production manager of Curtiss Wright Corp., returns to Bellanca Aircraft, as new president.

Elmer R. Crane has been named general manager of radio division of Lear Avia.

Edward Curtiss Wells, chief engineer for Boeing Aircraft, was named "Seattle's Young Man of the Year" by Seattle Junior Chamber of Commerce and was awarded Distinguished Service Key.

Sylvester J. Roll is named asst. to general traffic manager, PAA. **Richard C. Walker,** advertising manager, is commissioned lieutenant in Navy and is now on leave from Pan American; and **Kenneth C. Gunter** is appointed acting advertising manager in his place.

Jerome G. Stock, Wright Aeronautical controller, and **Walter R. Hart** secy-treas. and comptroller of Aircraft Industries Co., have been elected to membership in Controllers Institute of America.

Joseph P. Ripley, New York investment banker, was nominated for election to United Aircraft Corp's board of directors.

Allan H. Mogensen, who has been conducting Lockheed's work simplification program, is on a temporary assignment for War Department and will be stationed outside of U. S.

J. K. Gannett, Austin Co. vice-president, and its eastern district manager since 1928, is appointed director of engineering.

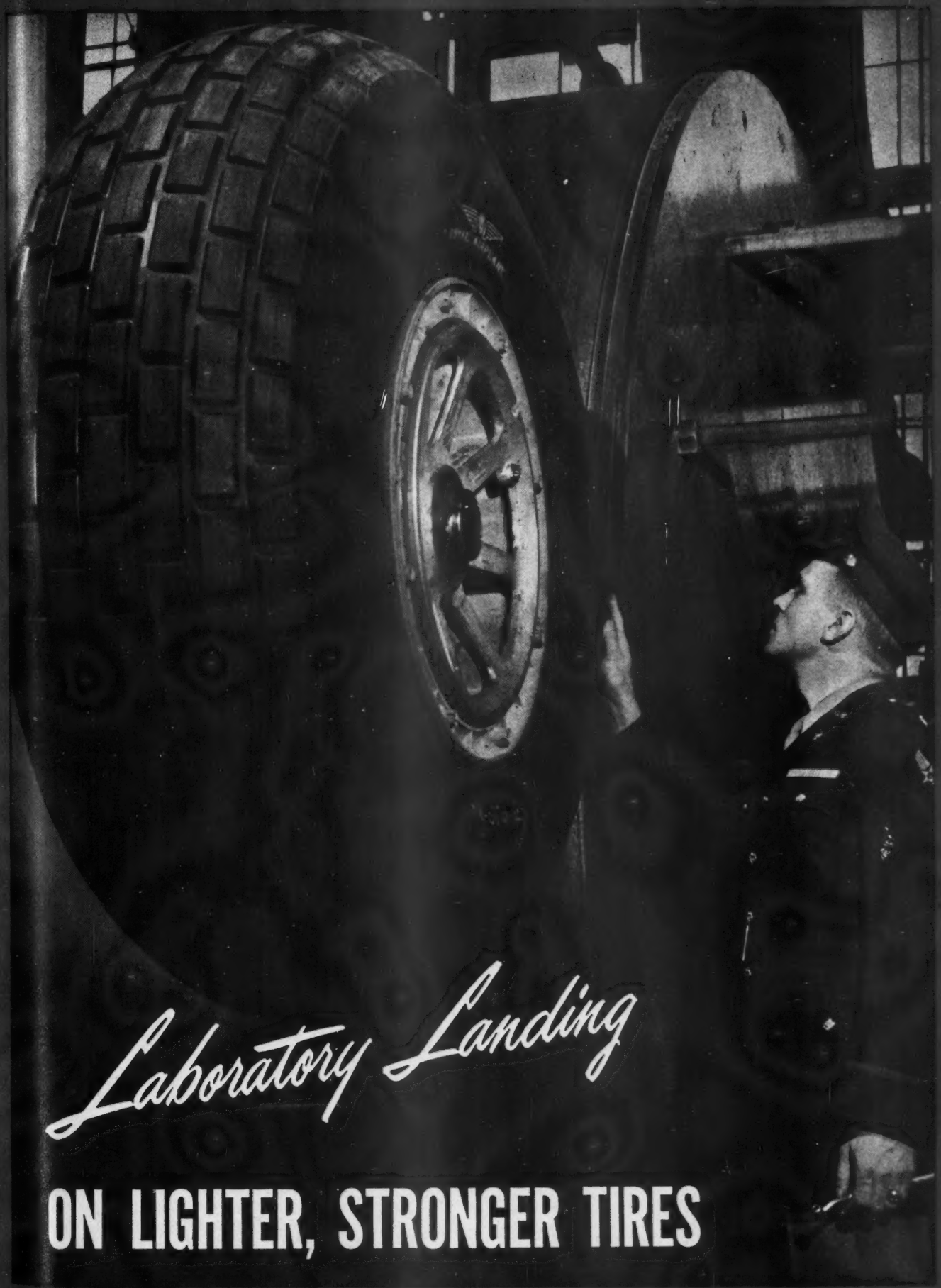
Floyd M. Williams is appointed general supt. of airmail traffic of American Airlines.

Comdr. James O. Biglow, USN, is appointed asst. Bureau of Aeronautics representative at Glenn L. Martin.

Realignment of Pratt & Whitney's engineering staff involves new titles as follows: **Guy E. Beardsley, Jr.** becomes asst. to chief engineer **Andrew V. D. Willgoos; Alexander H. King** is appointed chief designer; **Andrew L. Riker** becomes asst. chief inspector; **Donald S. Hersey** succeeds Beardsley as chief of auxiliary development; and **John H. Marchant** is assigned to head a new division having to do with fluid mechanics and heat flow. **Benjamin T. Howes,** as project engineer, takes over engine cooling and volumetric efficiency. Former engine group becomes section "A", and in this section **Augustus Hasbrouck** is appointed chief design engineer. Meanwhile **Lawrence Castonguay, Harry W. Gunberg, Nathaniel Haynes, Philip P. Newcomb,** and **Lewis M. Potter** become design project engineers. Former production engine group is now section "B" and will be headed by **Gilmoure N. Cole** who continues as chief design engineer; **Erwin Beyer, Carl N. Furay, John S. Hasbrouck, Charles A. Morss** and **Chester R. Wells** are design project engineers.

R. B. Moon, former chief of receiver development at Bendix Aviation's radio division, is named Pacific Coast branch manager of radio division.

Al J. McCullough and **Jack E. MacConville** are placed in joint charge of industrial instrument sales for Brown Instrument Div. of Minneapolis-Honeywell. **Kentner L. Wilson** becomes branch manager of Detroit office.

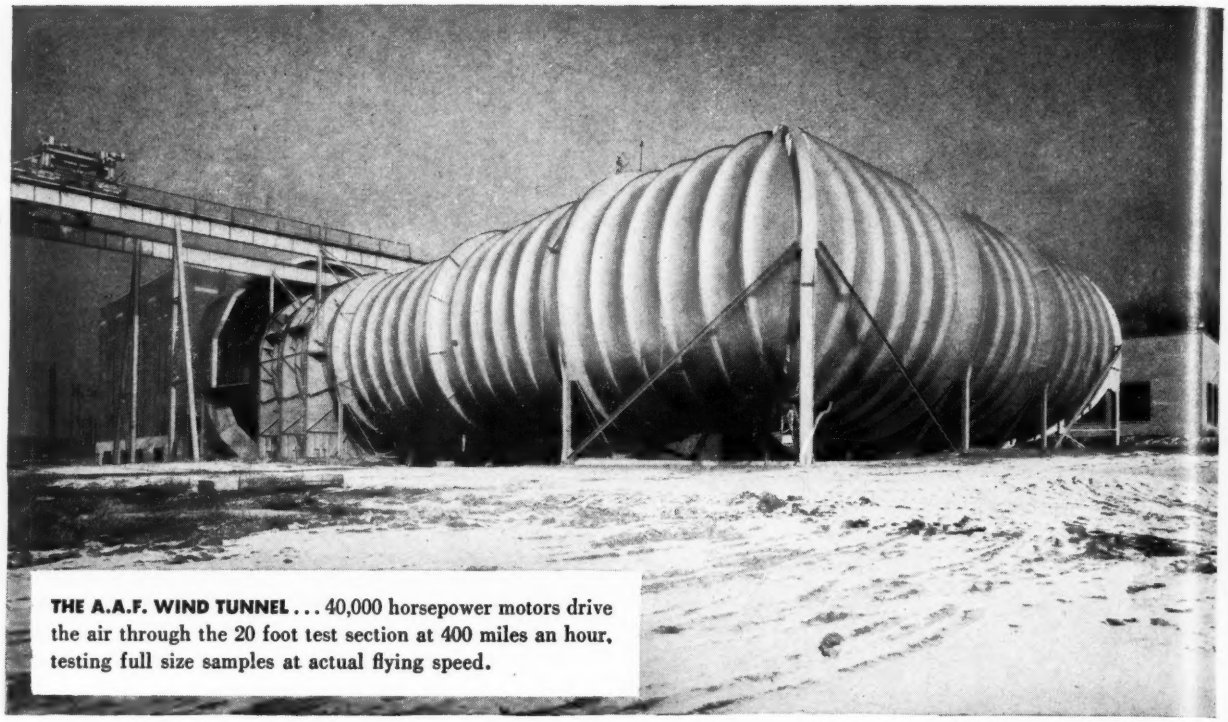


Laboratory Landing

ON LIGHTER, STRONGER TIRES

UNITED STATES RUBBER COMPANY

1230 Sixth Avenue • Rockefeller Center • New York 20, N. Y.



THE A.A.F. WIND TUNNEL . . . 40,000 horsepower motors drive the air through the 20 foot test section at 400 miles an hour, testing full size samples at actual flying speed.

Official Photo U.S Army Air Force

FINDING TOMORROW'S ANSWERS TODAY!

The Army Air Forces must have the answers to tomorrow's questions — today.

That is why in 1917, the War Department established an aircraft engineering laboratory at Dayton, Ohio. Since that time, AAF technicians from this field have worked hand in hand with airplane tire manufacturers to build lighter, stronger, safer tires, to build better equipment for every type of service in the air.

Today in a giant, 400 mile-an-hour wind tunnel, they are testing new types of radio antenna masts electroplated by the United States Rubber Company's Ekko Process and many other important new developments. In the Materials Lab they are testing cotton and rayon and nylon cord.

In service and in combat they are piling up data under actual flight conditions . . . and passing that information on to American industry. And from the war theatres of the world, the experience of combat fliers channels back to the nation's builders of airplanes and airplane equipment.

Planning, testing, searching far into the future, the AAF, working with industry, is keeping our Air Forces out in front of the enemy in fighting power — by finding the answers to tomorrow's questions today.

• • •

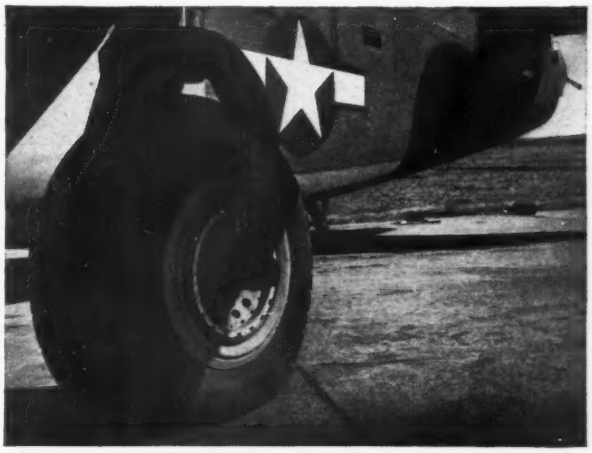
For the invaluable cooperation of all branches of the Army, Navy and Merchant Marine in their constant effort to improve the equipment of our fighting men United States Rubber Company expresses its sincere appreciation.

1230 SIXTH AVENUE **UNITED STATES**

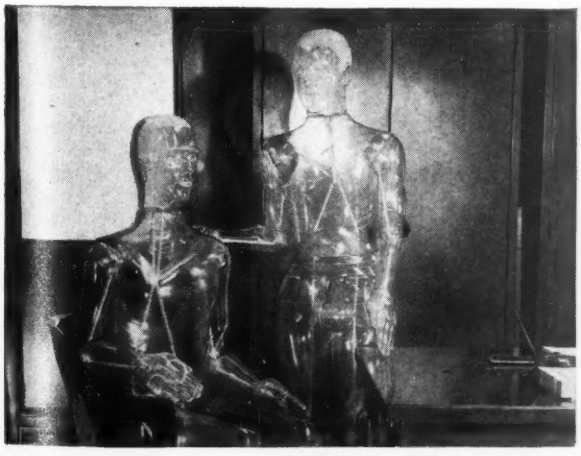
HOW THE AAF HELPS INDUSTRY BUILD BETTER EQUIPMENT FOR OUR FIGHTING MEN

Official Photo U.S. Army Air Force

LABORATORY TESTS . . . In the Materials Lab of the AAF all parts of the tire are tested, the findings tabulated, compiled and reported to the tire makers. C. J. Cleary, Assistant Chief, Materials Lab says, "Give us a material that has no weight and no mass and having infinite strength — and we will have reached our ultimate goal."



COMBAT TESTS . . . In actual combat and in service tests the performance characteristics of all types of tires are constantly checked. U.S. Royal Airplane Tires with bodies built of rayon or nylon and treads of synthetic rubber along with tires of all other manufacturers are tested. The results are passed along to "U.S." and other tire makers.



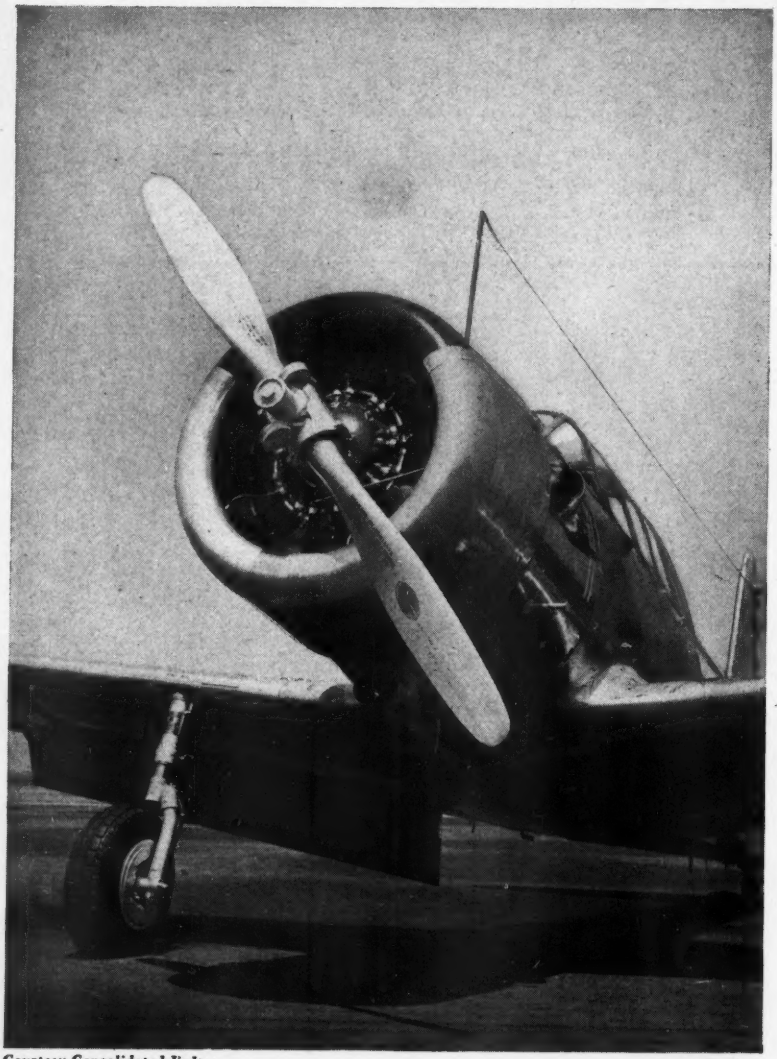
Official Photo U.S. Army Air Force

THE PLASTIC MEN . . . The Aero-Medical Lab studies the effect of high altitudes and low temperatures on flying personnel. Using plastic men like these, designed by skilled anthropologists, after careful study of Air Force personnel measurements, the AAF tries out "U.S." clothing and footwear.

Official Photo U.S. Army Air Force

PROPELLER TESTS . . . On this 6,000 horsepower electric whirl rig, the Propeller Lab applies the torture test to the latest types of propeller equipment. On these whirl rigs, United States Rubber Company's latest development for the elimination of ice on propeller blades gets an accelerated adhesion test.

RUBBER COMPANY ROCKEFELLER CENTER • NEW YORK 20, N. Y.



Courtesy Consolidated-Vultee

PROVED

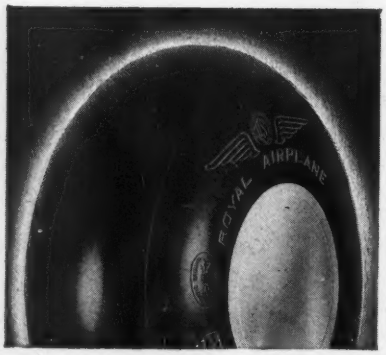
in the Laboratory in Service Tests and in Combat

There has been no guesswork about U.S. Royal Airplane tires. Every tire in the line has been tested in the laboratory, tested again under the closest observation . . . and then subjected to the most severe test of all . . . actual service.

The U.S. Royal Block Tread has proved itself on fighters, bombers and commercial airliners on almost every kind of landing strip . . . on our airports at home and on emergency landing fields in Africa, Italy and the South Pacific. Scientifically engineered for the greatest traction and serviceability, the U.S. Royal Block Tread is a standard among airplane tire designs. With the switch to synthetic rubber treads, the U.S. Royal Block Tread is again proving its stamina.

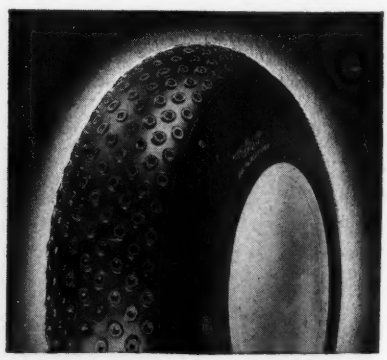
The U.S. Royal Ice Grip with its positive, non-skid grip on icy runways, the U.S. Channel Tread and the U.S. Royal Plain Tread nose and tail wheel tires each does its own specialized job safely and dependably on test...and in service.

SERVING THROUGH SCIENCE TO SPEED THE VICTORY



U.S. ROYAL SMOOTH CONTOUR TAIL WHEEL TIRE . . . Like every U.S. Royal Airplane tire, the tail wheel tire is available in Static Conductor Construction to protect the plane and crew from static shock. Specially designed for the stresses and strains of tail wheel service.

U.S. ROYAL SMOOTH CONTOUR BLOCK TREAD . . . The sharp edges of the U.S. Royal Block Tread protect against either forward or lateral skids...give sure-footed safety in landings and take-offs and deliver long, dependable service. It is the leader of the "U.S." Airplane Tire line.



U.S. ROYAL SMOOTH CONTOUR ICE GRIP . . . This radically different type of airplane tire tread design originated by United States Rubber Company has proved in tests on ice covered landing fields its ability to cut through ice and bring the plane to a safe, sure stop.

UNITED STATES RUBBER COMPANY

1230 SIXTH AVENUE • ROCKEFELLER CENTER • NEW YORK 20, N. Y.

AMERICA AT WAR

Aviation's Communique No. 29

Two years after the Air Force was established as one of the three component forces of the Army, Gen. George Marshall, chief of staff, says it is approaching complete air supremacy in practically every theater—and at a much faster pace than had been expected.

With 2,385,000 men in 11 air forces overseas, and four air forces plus many training establishments within U. S. borders, Army aviation is at its peak, accordingly is stopping personnel transfers from the ground forces. Nine weeks have been added to the fighter pilot's training period, five weeks to the schedule of bomber pilots, and important extensions have also been made in other phases.

CAA's War Training Service and the primary and basic schools contracting directly with AAF are all being curtailed and will be eliminated in a matter of months. The Army stopped initial training courses entirely some months ago, leaving it all to civilian schools. From now on, only enough new trainees will be taken in to serve as replacements. The Army may eventually resume schooling them itself.

But as the Air Force reaches the height of its power, inflicting losses of 3.8 on the enemy to 1 of its own, dropping nearly 10,000 tons of bombs on Europe in one week, and devastating large areas of enemy productive and military works, it also meets with some disappointments. The Air Force command says it knew what not to expect from its heavy bombardment of Cassino. But the enemy stayed there and the public didn't understand why. Though such works as Germany's ball bearing sources were badly wrecked, Nazi fighters keep on coming up—taking 96 Allied planes one day, and 80 American planes another.

Luftwaffe Shifts

Compared with damage inflicted, and with losses of men sustained by the Russian ally, attrition of British and American aviation is not too bad. AEF destroyed 11,042 Axis aircraft in all theaters, in the air and aground, in 1943, at a cost of 2,805 of its own. Though Nazi fighter resistance often is concentrated with deadly effect, just as often allied air missions swarm over Hitler's Europe at will, seeing none or few hostile aircraft.

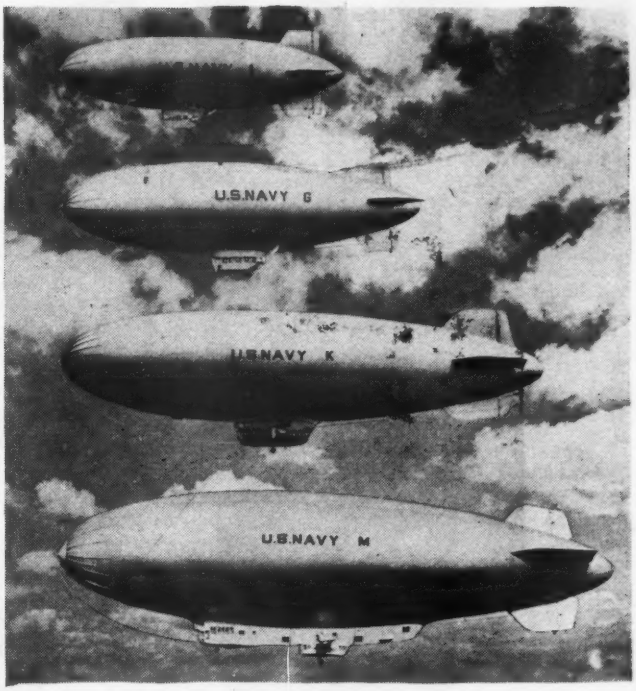
The Luftwaffe shifts its air defense rapidly—from Italy to France to Berlin—to cover its weakness. Allied air commanders still hope that, between hacking away at the invasion coast, supporting the Italian attack, and doing other jobs, they can smash enough of the enemy's aircraft plants so that what remains of Hitler's air power can be knocked down. Even then, if Italy is a true lesson, the walking Army will have no cinch. Presumably German engineers are doing an even better job of fortifying the French coast than they did south of Rome.

Other points to note: AAF heavily attacked Budapest for the first time . . . The British again put the Nazi battleship "Tirpitz" out of action as she lay in a Norwegian fjord . . . American bombers are filling more than half of their capacity with oil magnesium fire bombs, which often prove more destructive than explosives . . . Along with bombs recently went leaflets showing Germans the comparative size of the B-29's, which will soon be upon them . . . The Army has called for new priority ratings on heavy artillery, to do jobs that airplanes cannot do . . . And dispatches say that naval bombardment will be important when the cross-channel battle starts. Churchill said, in his war summary, that British - American air forces now can send up 1,000 bombers to the enemy's 100, adding that the allies have leadership in radar, both for attack and defense.

Pacific Successes

In the Pacific, the Navy has hit the Palau Islands, only 600 mi. east of the Philippines. The Japanese people believe that their navy is backing away to draw the United States into a trap, but everyone else sees that the enemy's sea power is not strong enough to match its opponents at long range. Allied aviation and sub and surface forces are pinching off Jap supply lines, and the island bases are withering. Truk, Jap main base in the Carolines, was recently pounded eleven times in six days, and it was due to be taken or by-passed.

An attack on the Philippines any time now would surprise no one. These islands are too far from Japan to be used immediately by us as a base for heavy air bombardment, but they stand squarely in the way of the direct route which Adm. Nimitz says he is taking toward a beachhead in China.



A SIZE FOR EVERY PURPOSE

Composite photo shows, proportionally in scale, four types of blimps built by Goodyear for Navy. "L" ship at top is 150-ft. primary trainer; "G" is 190-ft. advanced trainer; "K" is 250-ft. sub patrol and convoy craft; and "M" is 290-ft. sub patrol-convoy job carrying crew of 10. Car of "M" is 115 ft. in length, with maximum width of 10 ft. and maximum height of 20 ft.

★ CANADIAN NOTES ★

By James Montagnes

Production has been started at Vickers, Ltd., Montreal, on Douglas DC-4 transports for use on TCA main lines after the war, according to an Ottawa announcement, which also revealed that development work is under way in the Dominion on jet engines and aircraft.

The government has ordered domestic divorcement of ownership and operation of airlines by surface transport organizations. It is stated that within a year after hostilities cease in Europe, Canada National Railways (TCA interest) and Canadian Pacific Railway (CPA interest) must relinquish their airline operations to separate companies.

Airports at Edmonton, Grande Prairie, Ft. Nelson, and Watson Lake, on Alaska Airway, will be improved this year.

Specific production figures were released last month; Canada, it's stated, will make 4,312 aircraft this year as against 4,133 in '43, with more combat planes included. "Lancaster" production is to go from the current 9 per month to 17 by May and 30 by December; "Mosquitos" from 33 to 52 per month by June; Curtiss "Helldivers" from the present 20 to 70 monthly by midsummer, 130 monthly by the year-end; and Consolidated "Catalinas" from current 37 monthly to 50 by December. Trainer production will be reduced. To mid-March this year, 39 "Lanks" had been delivered and 183 "Mosquitos" built. Poundage has jumped from 1,628,118 in '40 (when 846 planes were made) to 20,088,864 last year (4,133 planes). Estimated poundage for '44 (4,312 planes) is 21,430,000.

A record Toronto-Winnipeg run of 3 hr. 5 min. was recently made by a "Lancaster" (7 hr. is the TCA schedule) . . . Canada is closing 28 air training schools . . . Capt. Roy A. Brown, DSO, DFC with bar, Canadian fighter pilot of World War I credited with shooting down Baron von Richthofen, recently died near Toronto at the age of 50. (Editor's note: Precise circumstances of the death of the "Bloody Baron" have remained a matter of controversy. Some World War I'ers claim he was killed by fire from the ground.)

Canadian Pacific Air Lines will establish its main overhaul and repair plant for both aircraft and engines in Winnipeg. It is also planned to transfer CPA's engineering division from Edmonton to Winnipeg.

An aerial survey of the Hudson Bay and Hudson Straits was made last summer, the RCAF reveals. Covered were 100,000 sq. mi. of Ungava Peninsula, Baffin Island, and the west coast of Hudson Bay.

By F. H. Fullerton

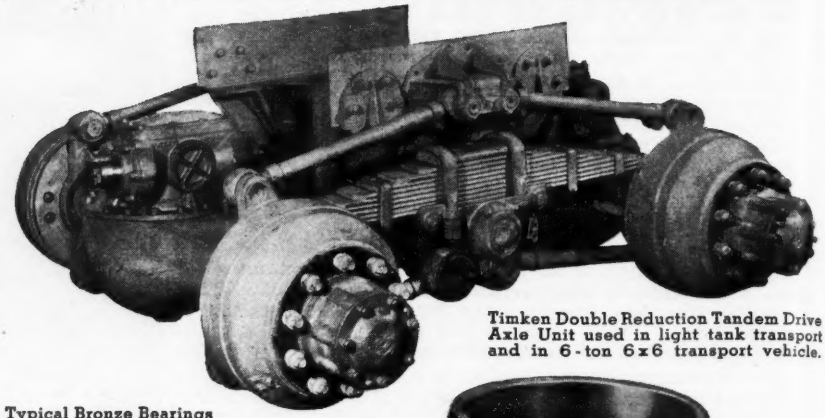
First magnesium plant for Vancouver, B. C., has been incorporated as Magnesium Foundry, Ltd., with capitalization at $100,000. Principal product of the new factory will be airplane parts. Magnesium supplies in ingot form will be shipped from the Eastern United States.

Erection of a new airport at North Vancouver, B. C., above the fog line, is now proposed. A large wooded tract is being examined, and surveying will not await the end of the war if possibilities are good. The tract is about the same distance from Vancouver's center as the present port on Sea Island.

Provincial Conference on post-war planning, called by the B. C. Shipyard Union Federation, was being held in Vancouver at press time. Employee delegates of Boeing Aircraft of Vancouver suggested that their plant make washing machines and other peacetime household equipment after the war.

AXLES of War

Typical Bronze Bearings used in Timken Axle applications.



Timken Double Reduction Tandem Drive Axle Unit used in light tank transport and in 6-ton 6x6 transport vehicle.

Timken Double Reduction Tandem Drive Axle Unit used in medium tank transport.

This Bunting catalog lists many sizes of finished bearings available from stock for axles and shafts and all industrial machinery applications. Write for it.

● Much of the rolling load of the Allied offensive is carried on Timken-Detroit Axles fitted with massive Bunting Bronze Bearings. Practically all types of automotive vehicles used in the war—high speed U.S. Army motor trucks, light and medium tank transports, transport vehicles—are so equipped to assure dependability in performance under the terrific stresses and shocks to which such units are subjected.

In the manufacture of bearings for these and other war equipment applications we have learned many things which will be of value to designers and manufacturers of machinery for war or peace. You will not be obligated in any way by discussing your bearing problem with our engineers and research staff. The Bunting Brass & Bronze Co., Toledo, Ohio. Warehouses in Principal Cities.

Bunting

BRONZE BUSHINGS • BEARINGS • PRECISION BRONZE BARS

New High Records—9,118 Craft, 103.4 Million Pounds—Set in March; Labor Turnover Up

Report company achievements . . . Re Model 39 and DC-7 . . . CPFF Still an issue

A new unit production record was set in March when the industry delivered 9,118 planes. In terms of airframe weight, production exceeded the million-pound mark for the first time, with an estimated 103,400,000 pounds including spares. C. E. Wilson, chairman of the Aircraft Production Board, said that 86.5 percent of the units were bombers, fighters, and transports. He congratulated the industry for its "remarkable over-schedule achievement."

There is reason to believe that in the future monthly unit output figure may fall occasionally below the March record due to constantly increasing weight of units, engineering changes, and the draft of men under 26.

The rate of labor turnover is still increasing in the aircraft industry. WPB puts the figure at 2.82 workers in Jan. 1942; 3.86 in Jan. 1943; 3.86 in Dec. 1943; and 4.31 in Jan. 1944. The Manpower Commission has some higher figures. But meanwhile, development of innumerable devices for maximum labor utilization is cutting down worker hours per pound of airframe produced. The figure for the Pacific Coast group, in Jan. 1943, was 1.67 direct man-hours per pound; by December it had been trimmed to .87 of a man-hour.

An official statement says the United States has produced 153,061 planes during the past three years, of which 105,126 were combat types. Average production is about 350 units per day. The Foreign Economic Administration announced that up to Mar. 1, 1944, 8,800 planes had been sent to Russia, about 4,000 of which were flown to their destinations. Majority were Bell P-39's, with many Curtiss-Wright P-40's, Douglas A-20 attack planes, and North American B-25 medium bombers. A previous FEA report said 7,000 planes have been exported and paid for in cash, mostly by the British. About 4,000 went to the Allied forces in the Pacific and Far Eastern theatres, with 16,000 to all other combat and training areas.

Report Company Achievements

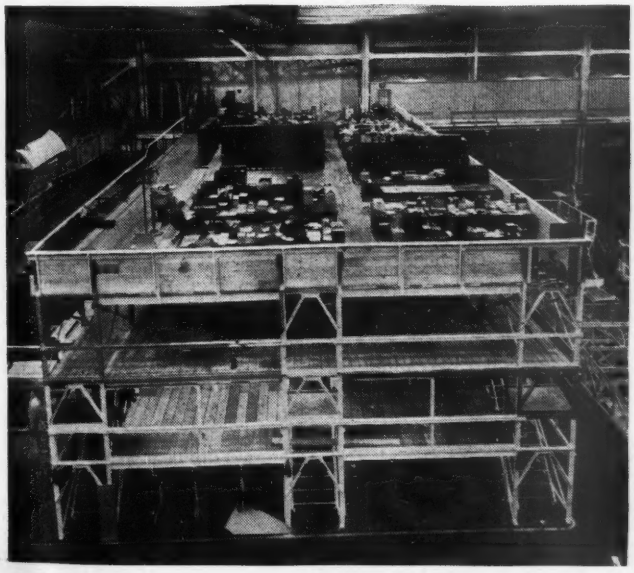
Boeing recently announced a world's record for a single month's delivery of completed four-engined bombers, "exceeding by a substantial margin the output of any other plant, American or foreign," and beating its own previous month by 25 percent. United Air Lines revealed that 3,500 B-17's had been processed in its Cheyenne modification center since early 1942, Continental Air Lines Denver center put through 1,600 B-17's since July, 1942, plus a few each of a British type and North American P-51's. Continental has exceeded its modification quotas monthly from 9 to 20 percent

From Wright Aeronautical came word that between Pearl Harbor and last Jan. 1, production of *Cyclone* and *Whirlwind* engines totaled an amazing 184,200,000 hp., termed by the report an all-time record for production of aircraft engines designed by one company.

Included were installation engines and spares built in Wright's Paterson and Cincinnati plants, also *Cyclone 9's* by Studebaker for B-17's and *Whirlwind 9's* of 400 hp. by Continental for tanks and gun carriers. Bulk of production was on *9's* (1,200 hp.) and on two models of the *Cyclone 14* (1,600 hp. and 1,700 hp.). Volume in '43 was swelled as the *Cyclone 18* (2,200 hp.) was put in quantity production—for new superbombers, other war craft, and also Lockheed C-69 and production versions of the Martin *Mars*.

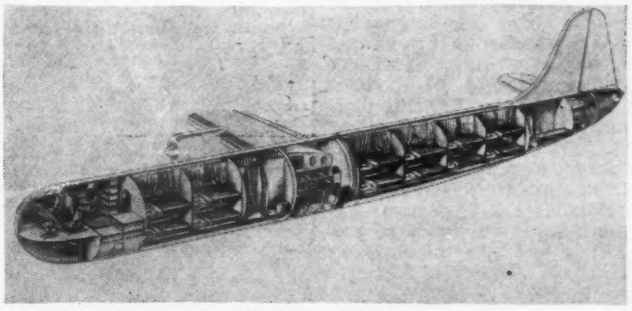
Republic Aviation has announced it has delivered more than 6,500 P-47's in the 48 months since the first model made its test flight. The *Thunderbolt* is mentioned with increasing frequency in front news; it escorts heavy and medium bombers, also attacks ground objectives with guns and bombs.

Allison engine production recently passed the 50,000 unit mark. The first Allison was flown in Dec. 1936 on an Army Bell A-11 fighter. Today, 50 percent of all U. S. Army fighters are powered by Allisons; included are P-39's, P-51's, P-38's, P-40's, and A-36



"DECKED OUT"

—to save space. Problem was Baltimore Martin plant critically needed extra manufacturing area—but where get it? Answer: Certain of huge PBM hull fixtures, no longer required, were floored-in, three-deck style, to give 22,464 sq. ft. of additional space to house timekeepers, industrial engineers, personnel counselors, and clerical workers. Thus old full-headroom office layout was obtained for plane making. An emergency proposition—but it worked.



CONVAIR BIDS FOR FUTURE TRANSPORT BUSINESS

Cut-away of Consolidated Vultee's Model 39, new 240-270-mph. passenger transport slated for flight tests late last month. Using B-24's wing, power plants, and landing gear, the 39 has 90-ft. fuselage length, compared with B-24's 66 ft. 4 in. Five cabin capacities are possible, ranging from 48-52 passengers for day runs to 24 for sleeper operations. With 48 passengers, baggage, and 1,200 lb. of mail, plane will have 2,500-mi. range. Basic gross weight is 56,000 lb.; provisional 62-64,000.

★ FOR THE RECORD ★

Waterbury Button Co., Waterbury, Conn., has changed its name to Waterbury Companies, Inc.

Evans Reamer & Machine Co., Chicago, formerly Evans Reamer Co., has moved to a larger plant in New Lexington, Ohio. Vice-President Hillshafer continues as general manager.

Duro Metals Products Co., Chicago, has started an addition to its Kildare Ave. plant.

Electrical Apparatus Co. has opened new offices at 1200 Soldiers' Field Rd., Boston.

Electric Service Supplies Co., Philadelphia, has changed its name to Electric Service Mfg. Co.

General Airport Co. has been formed for purpose of building and operating airports. Offices are at 101 Park Ave., N.Y.C.

Cutler-Hammer, Inc., Milwaukee, has opened a new office in C. of C. Bldg., Columbus, Ohio.

Aviation Associates, a firm of consultants for industry, has been formed, with offices at 664 N. Michigan Ave., Chicago, and 510 Camp St., New Orleans.

Briegleb Aircraft Co., Van Nuys, Cal., announces that it is developing new additions to its line of gliders and sailplanes. Erratum: This firm was erroneously listed as Sailplane Corp. in our February directory number.

Rogers Machine Works has moved its offices to 1807 Elmwood Ave., Buffalo, N. Y.

Globe Corp., Joliet, Ill., has acquired assets of Frankfort Sailplane.

Bendix Aviation Corp. has leased space at 71 West 23rd St., N. Y. C.

jobs. Engine No. 1 was rated 1,000 hp.; No. 50,000, 1,800.

Re Model 39 and DC-7

Consolidated Vultee has released some details on its Model 39, scheduled to be test-flown this spring at San Diego. Mounting four 1,100-hp. Pratt & Whitney engines, this plane may not be in the postwar "large" class, but it is considered a practical size (see illustration top last page).

Douglas DC-7, postwar airline design, will carry 86 passengers by day or sleep 76. It will have a span of 173 ft. 3 in.; fuselage 123 ft. 4 in. long; over-all height 43 ft. 8 in.; gross weight 85,890 lb.; useful load 59,100; speed estimated up to 400 mph.; and cruising range 4,000 mi. Called for is supercharged cabin, and ceiling is estimated at 40,000 ft. Cost will be around $1,250,000. Craft will be equipped with tricycle gear, two wheels each leg; and specified are four 3,000-hp. engines.

CPFF Still an Issue

A battle between Congress and the Army and Navy over cost-plus-fixed-fee contracts was not ended at press time. War Contracts Subcommittee of House Military Affairs Committee was considering a resolution to stop or drastically curtail this form of contract, favor being expressed for the fixed-price type. The Armed Services insist they must have the CPFF type in some cases. Aero Chamber Pres. James P. Murray, addressed to the Committee a statement contending that there is as much incentive under CPFF contracts to produce as under fixed-price agreements. He said that elimination of flexibility under CPFF contracts would impede the war effort.

★ ASSEMBLY LINES ★

Boeing is converting its huge Seattle Plant 2 for production of B-29 *Superfortresses.* Thus, company will put its entire effort into the new craft, both Wichita and Renton having already gone to work on B-29's. Douglas and Lockheed will continue on B-17's.

United Air Lines ran 3,500th Boeing B-17 through its Cheyenn modification center.

Goodyear Aircraft completed its 1,000 FG-1 "Corsair" less than a year after delivering first one to Navy.

Curtiss-Wright hollow steel propeller designed, tested, and produced in less than eight months, are giving Republic P-47 "Thunderbolts" 30 percent faster rate of climb, according to Robert L. Earle, C-W Propeller Div. vice-president and general manager.

Lockheed opens new $100,000 radio testing station in Santa Monica mountains, 6 mi. from main Lockheed plant and on "line of sight basis" for all of major southern California plants. Equipment includes 14 receiving sets and seven transmitters permitting operation across entire range of radio frequencies.

National Electric Manufacturers Assn. has opened an information center at 155 E. 44 St., New York City, under direction of John M. Moorhead, formerly of N. Y. "Herald-Tribune" and Kansas City "Journal."

Breese Corp. employees' accident rate dropped 59 percent in 1943 despite 30 percent increase in number of workers, Pres. J. T. Mascuch reports.

Aircraft industry separations in January were 6.16 per 100 employees, compared with 6.13 in Jan., 1943, reports WMC.

Convair's Vultee Field Div. will fabricate outer wing panels for the Navy version B-24 bomber. This new project marks new emphasis on combat craft as BT-13 trainer production tapers off.

WPB removed restrictions on aircraft grade Western hemlock, since Sitka spruce and Noble fir are being produced in sufficient quantities.

PRODUCTION-BATTLE CITATIONS

★ **Two Stars** ★

N. A. Woodworth Co.
Bound Brook Oil-Less Bearing Co.
U. S. Rubber Co. (Mishawaka plant)

★ **One Star** ★

Bristol Co.

Army-Navy "E"

Aircraft Accessories Corp. (Burbank plant)
Aeronca Aircraft Corp.
Chase Brass & Copper Co.
Goodyear Tire & Rubber Co. (Kelly-Springfield plant)
Gray Mfg. Co.
General Electric Co. (Erie plant)
E. F. Johnson Co.
Langley Corp.
P. R. Mallory Co.
Morse Instrument Co.
Monarch Machine Tool Co.
New York Air Brake Co.
Reliance Mfg. Co. (Triumph plant)
Sillcocks-Miller Co.
Silver Creek Precision Corp.
Simplex Products Corp.
Western Automatic Machine Screw Co.
U. S. Motors Corp.
U. S. Rubber Co. (Naugatuck plant)
Verson Allsteel Press Co.
Yoder Co.

UAL's Cheyenne modification center recently put finishing touches on its "3,500th Headache for Hitler"—one more in the steady stream of B-17's passing through the center.

Completing collation of February figures, AWPC West Coast reports member output for the short month jumped to all-time high of 32,469,000 lb. (2,569 planes). While only 10 more craft were made than in January, weight was up 577,000 lb.

★ KNOW-HOWS ★

One idea every five hours is the year's record of Goodyear Tire & Rubber Co's "Idea Assembly Line" which has put 1855 employee ideas to work. In all, Goodyear paid $57,000 to employees for these ideas, of which $37,000 was paid to aircraft workers.

DuPont has found a new use for cellulose sponge—filling of wing spaces around self-sealing fuel tanks to absorb the small leakage inevitable after perforation by bullets. By treating with Aridex water repellant, sponge is prevented from absorbing moisture and thus adding to plane's weight.

Bendix saves 800 tons of metal per month at South Bend plant by segregating metals into alloy types throughout all production stages. Also saved are 84 tons of paper through a "Don't Burn Anything" program, while nationwide salvaging of old automobile carburetors has brought in 10,000 lb. of zinc and 5,000 lb. of aluminum.

Foundry air in magnesium plant of Eclipse-Pioneer Div. of Bendix, is conditioned at the rate of 45,000 cu.ft. per min., enabling large numbers of women to be employed unendangered by fumes.

Lear Avia's President, Wm. P. Lear, told the combined meeting of Franklin Institute and AIEE that electro-mechanical control systems for aircraft had achieved such a high peak of efficiency that there is not a single known instance where any American plane has turned back from failure of the electrical control system.

Ohmite Mfg. Co. has a new system of hammer-testing of castings or forgings. Sound of the blow is picked up by a microphone, amplified, then passed through a filter to suppress harmonic frequencies. Remaining base frequencies indicate whether material is sound.

Elastomers of a new type are announced by B. F. Goodrich Co., which combines plasticized vinyl chloride resins with butadiene type synthetic rubber to effect vulcanizable blends reported to possess best qualities of both materials. Company states this is first time gap between plastics and rubbers has been closed.

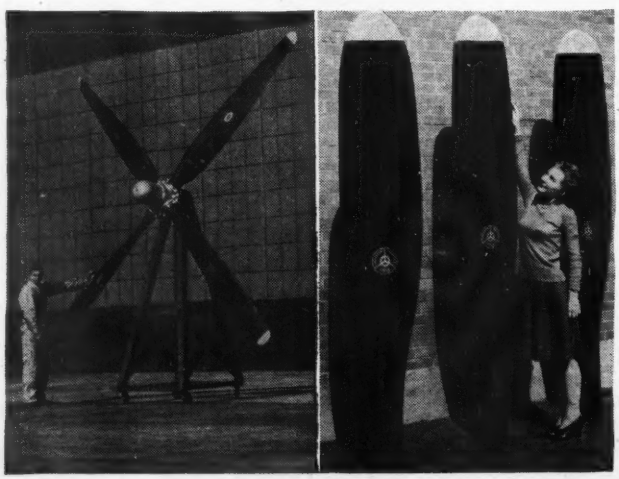
Transparent plastics are replacing metal castings in many complicated accessories, according to Glenn L. Martin, thereby saving much time in inspection and enabling learners to grasp methods of operation quicker.

Substitution of 1/32-in. rubber sheeting for grease in Glenn L. Martin's stretching machine dept. has resulted in increase of 50 percent in output and saving of both material and labor. By old method sheets were greased and later scraped clean by hand, after which they were given a vapor bath. Through use of rubber sheets, cost of operation has been decreased by saving of labor. Also cited is reduced price of rubber compared to that of grease as applied.

Two engineers, Marshall G. Whitfield and Victor Sheshunoff of Al-Fin Corp., a Fairchild subsidiary, have prefected method whereby chemically pure aluminum and steel may be bonded. Process has been used in combining steel cylinders with aluminum cooling fins on Fairchild V-12 engines, with saving in weight and considerably added efficiency.

Electrically heated anti-ice "skin" for propellers is one new development announced, and anti-ice propeller-blade "boot" is another. Former was brought out by B. F. Goodrich, working in conjunction with NACA, while latter is Goodyear Rubber Co. product. Of conductive synthetic rubber, "skin" operates like household electric heating pad and is especially for use where standard pulsating deicer cannot be applied. Goodyear unit, also using synthetic rubber and employing electricity, is additionally stated to protect blade from small objects, such as sand and pebbles.

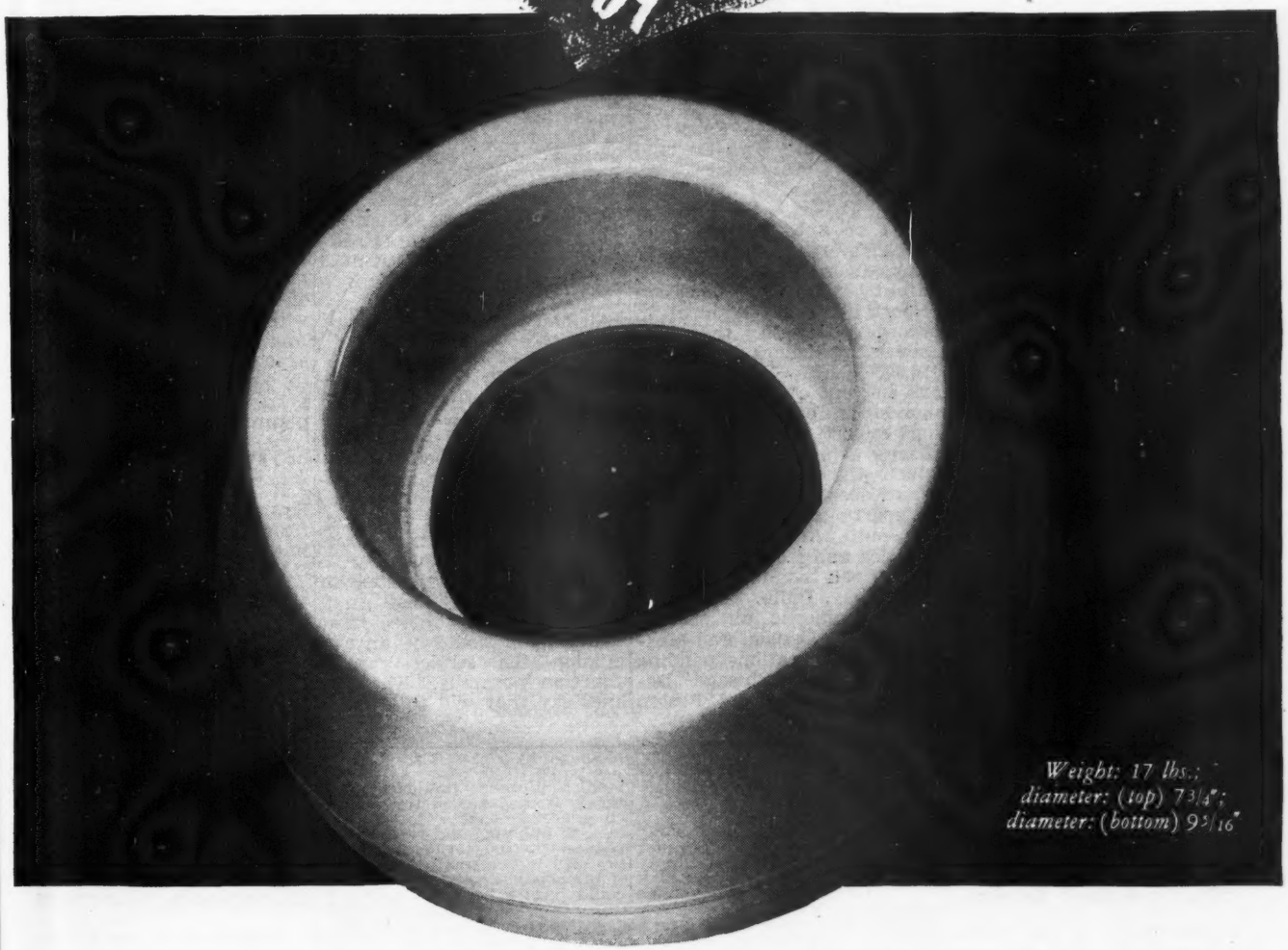
Army considers substitution of aluminum or magnesium for steel in runway mats. Which of two light metals is to be favored has not yet been decided, but both metals, because of weight factor, afford shipping and handling convenience. Story that heat reflection from light metal in landing mats would cause troublesome air turbulence has been discredited.



BIGGER AND BETTER

Four-blade Hamilton Standard "Hydromatic" propeller (left) is called "largest airplane propeller being produced on a quantity basis." Right: Blades of 16 ft. 6-in. dia. Curtiss electric propeller to be used on 20 Martin JRM-1 "Mars" cargo transports.

ALUMINUM DIE-PRESSED FORGING by REVERE



The cylinder barrel muff which we illustrate is typical of the strong close-grained, die-pressed aluminum forgings in which Revere has pioneered so successfully—especially in the aviation industry.

This particular cylinder barrel muff is used in certain types of radial aircraft engines and with special success in one of the famous engines extensively used by the Navy. When finally machined, the resultant thin fins reach almost to the core of the cylinder itself and provide an unusually large cooling surface.

Revere forgings are also available in copper, various copper-base alloys and magnesium. Almost any shapes and sizes can be had, even those ordinarily pronounced "impractical" or "impossible".

Revere will be glad to offer—*without obligation*—technical advice on any special problems you may have in die-pressed forgings. Write Revere Executive offices.

FREE! A 54 page manual, "Revere Copper and Copper Alloys—Technical Information for Product Designers," with 106 graphs relating to physical and metallographic properties under varying conditions; also, a new, easy-to-read chemical and physical properties chart, with pertinent illustrated information on Revere manufactured forms and welding technique. A complimentary copy sent you upon request. Address: Executive Offices.

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Transport Aviation

McCarran Triggers Third CAL-Revision Bill; AA-AEA Move Jells "Competition" Drive

Form Feeder Association . . . CAA starts Airport Survey . . . Airmail remains problem . . . Ryan files for six feeders . . . Busmen plan air service

Sen. Pat McCarran (D. Nev.) has introduced a third bill in Congress to revise the civil air law of 1938. The other two are the Lea bill, introduced over a year ago, reported to the House Interstate and Foreign Commerce Committee, and withheld from House debate by the House Rules Committee; and the Reece bill, representing the minority opinion of the Commerce Committee, which was not reported.

McCarran's bill covers overseas air transport as well as domestic, providing for a billion-dollar American foreign service corporation in which any or all certificated operators could participate, a set-up arranged so no single one could get control. It would abolish the Civil Aeronautics Board and also the Civil Aeronautics Administration, creating instead a seven-man Civil Aeronautics Authority with an Executive Officer to carry out its orders.

An independent Air Safety Board would be established to investigate all civil air accidents. States would control intrastate carriers and contractors; "experimental" certificates would be issued to advance feeder service; a "bill of rights" would be provided for private flying; and a new national airport survey would be authorized.

Export Merger Would Create "Double Action" Service

In the wake of the initial announcement (page 202 Apr. AVIATION) that American Airlines has moved to purchase a controlling interest in American Export Airlines, there has come a growing understanding that this development is a very confident—and decided—step toward a competitive U. S. overseas air system. That is, a system definitely opposed to a single-management corporation.

As this was written, there was no apparent reason why CAB would not approve the merger, even though it is granted that the deal might conceivably be knocked out if Congress should legislate in favor of airline participation in a "chosen instrument" management.

American Airlines would acquire Export's permanent New York-Lisbon certificate, which is not now in use because Portugal is non-belligerent and because Pan American has exclusive landing rights there. American would acquire also the temporary certificate (expected to be converted to permanent) on which Export is operating New York-England and New York-Africa via South America.

For Export, the merger would be a complete answer to CAB's order that the company divorce itself from its parent company, American Export Lines (steamships) in accordance with the law. American Airlines would get 120,000 shares, a controlling 51.4 percent of Export's common stock, for $3,000,000, leaving Export steamship 46,000 shares, a minority interest to which the Civil Aeronautics Board does not object.

Export has applied for routes to South Africa via South America and from Natal, Brazil, through the Mediterranean to Bombay, India. American, largest domestic air system, also serving Canada and Mexico, has applications pending for lines from Chicago, Detroit, New York, and Boston to London. The alliance, which would link this biggest of domestic operators with the only competitor of Pan American, would create the first "double-action" domestic-overseas service.

Form Feeder Association

Feeder Airlines Assn. is a new organization formed at Washington, D. C., to include both present operators and new applicants for air pick-up and feeder air routes. Sixteen companies were represented at the meeting which launched the new body. Named was an acting organization committee, with Harry R. Stringer, vice president of All American Aviation, as chairman. Headquarters were opened at 1029 Vermont Ave., Washington.

Airmail Remains Problem

Aspects of the airmail rate increase from 6 to 8c., combined with a growing percentage of delayed service, found Postmaster Gen. Frank Walker and Airmail Superintendent Roy Martin touring the country, seeking some answer to the problem-packed situation. Public complaint is increasing. Army long ago advised P.O. to install a priority system to handle important mail first. Post office seems to feel that such a step would be an admission the service cannot function normally. The airlines say they will fly all the mail if they are given enough airplanes.

Thompson on Airport Survey

CAA's newly established Airport Building Design unit has now gone into action, with Marc Thompson, its head, currently touring the country to study design trends and requirements. Facilities and space requirements will be accented in the long-range approach, which will include consideration of administrative buildings for future private-flying ports as well as terminal needs for air carrier operations.

Thompson's study is part of a three-phase CAA plan. A CAA unit to compile data on management methods, intended to take airports "out of the red," was formed earlier, with J. Kirk Baldwin as chief. And in the near future, CAA expects to form a third unit to consider the place of airports in integrated community planning.

Ryan Files for Six Feeders

If the new application by Ryan School of Aeronautics for six feeder and pick-up airline routes is approved by the CAB, more than 100 California cities will be added to the list of communities served by air transport facilities.

Routes solicited are Los Angeles-San Diego, Los Angeles-Yuma, San Francisco-Los Angeles, San Francisco-Bakersfield, San Francisco-Redding, and San Francisco-Eureka. Over the total of 2,100 route miles, Ryan proposes to fly 5,400 mi. daily, employing twin-engine craft equipped with pick-up devices to service communities lying between the regular passenger stops.

Busmen Plan Air Service

Announcement also came that the newly incorporated Dayton & Western Ohio Airlines, headquartering at Dayton, Ohio, would file for a new system of feeder lines to serve 19 Ohio and Indiana cities, at least 11 of which do not now enjoy such facilities. The company, formed by three interurban bus outfits, plans use of both conventional aircraft and helicopters. Operation would be between Cincinnati, Dayton, Columbus, Toledo, Lima, and Portsmouth in Ohio and Richmond in Indiana.

Company board chairman is Walter A. Draper, president of Ohio Bus Lines and the Cincinnati Street Railway Co.; and company president is William L. Butler, president of the Cincinnati & Lake Erie Transportation Co.

. . . . And We Quote

"The airlines are suffering badly from lack of planes and cannot get from the Administration any information as to even a plan for returning the airplanes seized on presidential order. This is hard to understand, since the production of this type of airplane is high and the diversion of factory deliveries of this type of plane for only one day would do much to speed the war work of the domestic airlines in the large priority loads they carry."—Ralph S. Damon, vice-president and general manager, American Airlines.

"The day of transport airplane standardization, as we have known it for the past seven years with the Douglas DC-3, is over, for as we [the airlines] grow we must provide a public service ranging from local passenger service operations to long-range passenger service, as well as air cargo facilities to the shipper of merchandise requiring speed of movement."—Charles Froesch, chief engineer, Eastern Airlines.

"Surplus plant and surplus war goods may even be considered in the nature of similar goods already expended in war. They are public property and should be administered in the public interest. The public interest demands a high level of employment. Forced liquidation of these items, as if they were commercial assets, with the idea of applying the recovery to reduce the public debt, would produce but a small percentage of the original cost. This return could hardly begin to approach the outlay for relief which would inevitably result from unemployment produced by disarranging the economy. If, however, we have clear recognition of these principles and courageous administration, we can emerge with a strong nucleus of an aircraft industry derived from those companies which have performed best in the war effort, particularly along technological lines."—Eugene E. Wilson, vice-chairman, United Aircraft Corp.

"It would be a serious mistake to suppose that we could put off all thought of postwar problems until the day the shooting stops. Actually, right now we are getting a foretaste of post-war conditions."—Tom Girdler, chairman, Consolidated Vultee Aircraft Corp.

"The airport of the future will be a community in itself, offering an opportunity for design on the grand scale. Wise planning and control of its development will enable every community to achieve a unified, simplied group of buildings from a small beginning."—Albert F. Heino, United Air Lines architect.

★ CROSS COUNTRY ★

Combined rail-air express shipments for January totaled 38,257, up 32.8 percent over 28,810 in Jan., 1943, according to REA.

Penn-Central carried 831,578 lb. of mail in January and February, a gain of more than 37 percent over 604,004 lb. moved in same period of last year. Express moved in same period totalled 626,433 lb., against 403,272 a year ago.

TWA made 3,159 trans-ocean flights during first two years of over-water operations for ATC, of which 1,647 were across North and South Atlantic. All flights were made in Douglas C-54's and Boeing 307 "Stratoliners." Mileage totaled 12,894,467; current operations cover over a 1,000,000 mi. a month.

United Air Lines flew 28,722,500 revenue passenger miles in February, up 29 percent over 22,255,444 in February of last year. Airplane miles flown totaled 1,921,140 against 1,570,522.

Hawthorne Flying Service has taken a 5-yr. lease on municipal airport at Rocky Mount, N. C. This first Hawthorne venture in North Carolina will be managed by Lee B. Borie, now flight instructor at Hawthorne's Columbia, S. C, Navy-WTS school.

Panagra has converted to all-cargo service one of three new DC-3's just alloted it; craft will supplement two DC-2's now used on the Balboa-Buenos Aires route.

Pan American Airways has purchased minority interest in Bahama Airways, planning regular schedules to all principal Bahaman islands after the war, tieing in with Nassau-Miami run.

American, Braniff, Chicago & Southern, Eastern, Pan American, Penn-Central, TWA, and United recently cooperated in striking "food flight." From four countries and five southern states they transported—in 6 to 30 hr.— tree- and vine-ripened fruits and vegetables to Detroit luncheon sponsored by Wayne University under E. S. Evans Grant for Air Cargo Research.

Penn-Central has asked to withdraw from CAB its application for routes into Caribbean, Central and South American areas, giving as reason its conclusion "that the national interest no longer required that PCA prosecute this particular application." Company will, however, continue seeking additional domestic routes.

Purchase of Mayflower Airlines by Northeast Airlines, announced last year and the subject of a public hearing this January, has been recommended for approval by CAB Examiner Frank A. Law. Okay by the board will bring routes between Boston and Provincetown, Hyannis, Oak Bluffs, and Nantucket under the NA banner.

National Committee for the Development of Aviation has been launched in Cuba to foster civil aviation. Plans are underway to build a system of municipal airfields.

More than 500 airfields have been made ready in Britain, a five-fold increase in five years.

Installation of six long-wave radio stations over the North Atlantic route has eliminated magnetic disturbances and speeded ferrying of planes to Britain.

Removal of "war paint" on Douglas C-54 "Skymasters" saves 200 lb. in weight and adds 7 mph. to normal 222-mph. cruising speed.

Book Reviews

PROCEEDINGS—THE FIRST NATIONAL CLINIC OF DOMESTIC AVIATION PLANNING. Oklahoma City Chamber of Commerce. 277 pages.

Addresses reprinted from Oklahoma City meeting held last November include the Domestic Air Pattern for Tomorrow, Harllee Branch; Future Pattern and Policy of Ground Facilities, W. A. M. Burden; A Suggested Pattern for Domestic Aviation, Col. E. S. Gorrell; Postwar Disposal of Surplus Aircraft, W. W. Parrish; Air Cargo Expectancy, C. P. Graddick; The Primary Transport—Local and Feeder Service, Gov. M. M. Neely and C. E. Leasure; The Personal Aircraft, J. T. Geuting Jr.; Renegotiation and Termination of War Contracts, F. A. Callery; Peacetime Plans for Wartime Plants, Rep. M. J. Maas and Rep. Jennings Randolph; Fixed Base Operation, Roscoe Turner and D. M. Steele; Technical Aviation Training, Assen Jordanoff and M. W. Balfour; The Further Vistas, G. R. Wilson; Education for the Air Age, F. G. Brewer, Drs. Bruce Uthus, F. W. Hart, and A. C. Willard; and The Helicopter, W. B. Stout.

GAS TURBINES AND JET PROPULSION FOR AIRCRAFT, by G. Geoffrey Smith. Aerosphere, New York City. 79 pages, illustrations, $1.50.

In the turbulent wake of speculation following announcement of military use of jet propulsion, this short book combines a wealth of j-p information. It is a reprinting of a series of articles which appeared in the British magazine "Flight" in Aug. 1941, and later.

"It is necessary," writes Mr. Smith (who is managing editor of "Flight" and of "Aircraft Production") "to distinguish clearly between two forms of jet propulsion. In one the thermodynamic unit is a vessel containing a combustible mixture which in itself embodies the oxygen necessary for combustion and is thus independent of the atmosphere. The combustion gases escape by a nozzle to form a propulsive jet. This is the rocket principle. In the other the thermodynamic plant uses a liquid or solid fuel that requires to be fed with oxygen from the atmosphere for combustion. This is the thermal jet system with which we are concerned . . . In the view of the author, combustion gas turbines hold great promise as a propulsive unit for aircraft of the future.

Mr. Smith's chapters consider rotary or reciprocating compressors, influence of jet upon aircraft design, potential advantages of jets, the Caproni-Campini plane, steam turbines, and types and possibilities of gas turbines.

THE ARMY READER, edited by Lt. Col. Karl Detzer. Bobbs-Merrill Co., New York. 469 pages, illustrations, $4.

This is the "anatomy book" of the army, a vast survey of machines and men trained in specialized tasks to be controlled as a formidable unit. A whole section is devoted to the air forces, with articles on and by Gen. Arnold, by Lt. Gen. Yount, Brig. Gen. Sorenson, and Lt. Col. Silsbee.

The specialties in the army itself have obliged Col. Detzer to chop the book up into little pieces, each dealing with one small subject. Practically all the material has been reprinted from magazine articles and thus, in the tremendous struggle for instantaneous progress, some of the information is of phases that may no longer be representative.

THE HELICOPTERS ARE COMING, by C. B. F. Macauley. Whittlesey House, New York. 165 pages, illustrations, appendix, $2.00.

Popularly slanted for the man-in-the-street (foreseen, one day, as becoming the man-in-the-air) Mr. Macauley's book aims to answer "the questions in the minds of everyone regarding the highly controversial subject of the helicopter's future" and to "help stimulate interest in the many ways the helicopter can surely serve us in recreation, travel, and daily work as it comes of age in the years ahead.

Following the various generic definitions of the craft, the many revealing incidents of the Sikorsky XR-4's memorable initial cross-country flight to Wright Field are recounted. Then, in turn, come a historical review tracing development of the helicopter, a discussion of its use and prospects in war, and an outline of commercial possibilities. Finally, in chapters titled, "The Helicopter and You," and "Social Impact," the author offers his forecasts in prospective perspective—of tomorrow's family "helicar" activity and its consequent effect upon our manner of living. The appendix lists organizations already engaged in, or contributing to, helicopter development. Highlighting the book are numerous amusing "helicartoons."

ILLUSTRATED TECHNICAL DICTIONARY, edited by Maxim Newmark. The Philosophical Library, New York. 352 pages, illustrations, $5.

"The plan of this dictionary is to supply a wide and representative selection of officially approved, standard definitions promulgated by various United States engineering, technical, trade and industrial organizations, as well as by government agencies." Primarily intended for engineering, technical, and trade libraries.

AIRPLANE DESIGN, by Karl D. Wood. Published by author at Purdue University, Lafayette, Ind. 2nd edition. Index.

A textbook of airplane layout and stress analysis. Mr. Wood is a professor of aeronautical engineering and a consulting aeronautical engineer.

FUNDAMENTALS FOR THE AIRCRAFT MECHANIC, by James M. Markley. McGraw-Hill Book Co., New York. 345 pages, appendix, illustrations, index, $4.

Designed to give a basic knowledge of aircraft, this text is for employment in conjunction with laboratory courses in the parts and care of hand tools. Also recommended are experiments in the subjects being taught. Fundamentals of sketching, blueprint reading, and shop mathematics are included.

BASIC AIRCRAFT INSTRUCTION, by Ross A. Peterson and Raymond E. Erickson. Prentice-Hall, Inc., New York. 204 pages, appendix, illustrations, index, $2.50.

Detailed explanations, in non-technical language, of various operations in the manufacture of all types of airplanes.

AIRPLANE PERFORMANCE AND OPERATION, by R. Dixon Speas. McGraw-Hill Book Co., New York. 121 pages, illustrations, index, $1.50.

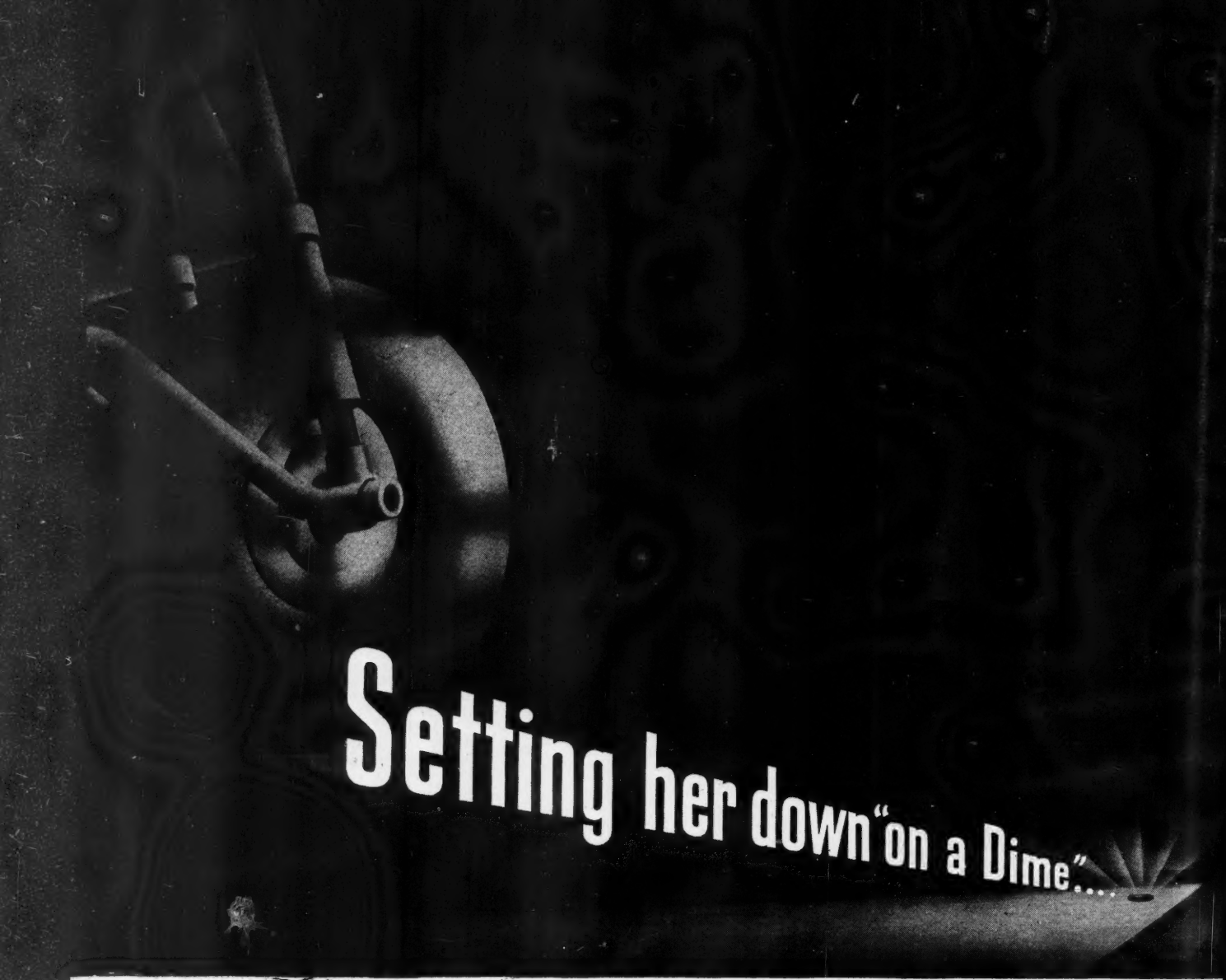
Flight crew instruction in the various technical factors affecting airplane performance and operation, with explanations of graphic and tabular forms of presenting performance charts. "This manual should prove as valuable for pilots seeking the means of self-instruction as for use as a text in the organized training of new transport pilots," states Dr. Edward P. Warner, Civil Aeronautics Board. Drawings of gremlins add an amusing touch to book.

TOMORROW WE FLY, by William B. Stout and Franklin M. Reck. Thomas Y. Crowell Co., New York. 160 pages, photographs, $2.

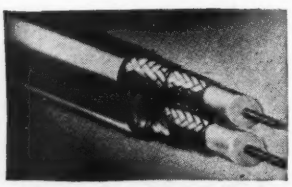
Discussion of commercial and private aircraft probabilities for the future. Facts and figures bolster the authors' contention that postwar transportation will increasingly take to the air.

QUICKIE SNIPPIE

Lockheed needed rotary shears in a hurry; AAF said they could have them. Douglas C-47 picked up two units, each weighing 2,000 lb., at Whiting Corp. plant in Harvey, Ill., flew them overnight to Burbank. Within 24-hr. of their completion, shears were operating in Lockheed plant.



Federal's Instrument Landing System is Ready to Serve the Great New Air Age



Federal's Instrument Landing Systems are equipped with Intelin Coaxial Cable, also developed and manufactured by Federal. This cable has extreme ruggedness, strength and endurance, and meets all specifications with precision, accuracy, uniformity and dependability.

Through fog, sleet, rain and blackness the science of radio brings the airliner home.

The pilot *knows* his course, position and landing.

Federal's Instrument Landing System guides the homing pilot with unfailing accuracy. He can set his ship down on a dime.

Federal's equipment has made a great contribution to safety in the air. It is dependable and, moreover, is less subject to atmospheric disturbances. It reduces initial, maintenance and operating costs.

Federal—one of the largest manufacturers of instrument landing equipment for ground installations—is prepared now to discuss your plans and probable requirements.

Federal Telephone and Radio Corporation

AN IT&T ASSOCIATE

Newark 1, N. J.

Reports on New British Power Plants and Planes

Brabazon Committee recommends seven craft . . . Vickers and Handley Page craft for postwar . . . Diary of British jetplane

Details are made public on two new British aero engines, the Napier *Sabre II* and the Rolls-Royce *Griffon*. While the *Sabre* has seen action for some time in the Hawker *Typhoon*, the *Griffon* is said to power a new British fighter (called the *Tornado* in some reports, and the *Tempest* in others and built by Hawker in either case). Salient in the 24-cyl. *Sabre II* are two equi-rotating crankshafts with two banks of horizontal cylinders, with the same cylinders in top and bottom banks firing together.

With 2,240 cu.in. displacement, the engine has a 7:1 compression ratio, and is stated to deliver over 2,200 hp. at 3,700 rpm. Its sleeve valves are operated by a special shaft driving cranked gears, and the two-speed supercharger features continuous drive from two torsion rods through an hydraulic clutch. Another interesting feature is the multiple-cartridge engine starter, to enable five starts without reloading.

The *Griffon*, latest in the long line of Rolls engines, has a displacement similar to the *Sabre*. Its horsepower performance, still on the restricted list, is thought to be around 2,100 hp. up to 25,000 ft. The *Griffon* is extremely compact, a feature mainly achieved through use of an external shaft-driven gear box on which all accessories are grouped.

British Committee Recommends Seven New Aircraft

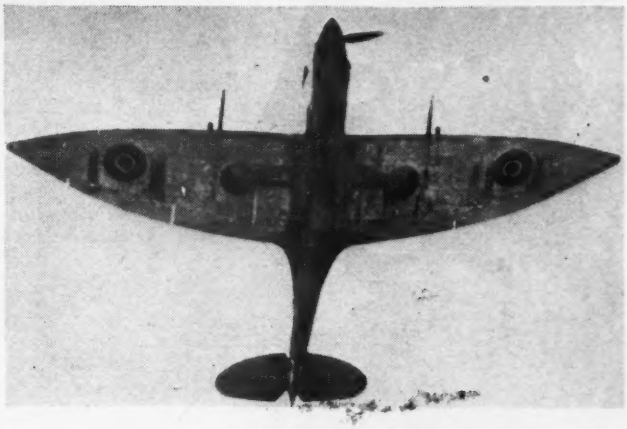
The second Brabazon Committee, dealing with Britain's postwar air plans, has recommended seven new aircraft to assure England's position in the new peace. The types run from an 8-passenger feeder-line plane, through a 14-seat land plane and several larger types, up to the giant 100-ton flying boat reportedly under construction at Bristol as a "spare time" project. The other plans include a jet-propelled passenger plane of unpublicized size, two pressurized land planes, of approximately 70,000- and 100,000-lb. gross weight, and a 30-passenger twin-engined land plane of some 40,000 lb.

Vickers and Handley Page Craft for Postwar

During recent weeks, two new warplane conversions for the immediate postwar period were announced in England—first, the Vickers *Warwick*, a twin-engined monoplane of 45,000 lb. with marked resemblance to the *Wellington* (geodetic construction), powered by 2,000-hp. Pratt & Whitney engines; and second, a new model put out by Handley Page, builder of the *Halifax*, which can carry up to 50 passengers. The latter plane, designed to use as much of the bomber's assemblies as possible, has a circular fuselage suitable for pressurizing. Its cruising speed is reported to be over 200 mph., with a payload of 9,500 lb. at an extreme range of 2,500 mi.

Diary of British Jetplane

To complete the background stories on the jetplane, some dates in its development have been made public. In 1933 final development work on the present type was started, in 1937 the first engine was tested, and in 1939 the first jet-propelled airplanes were ordered by the government from Gloster. The Gloster plane flew initially in May 1941, Gen. Arnold received full information in July, and the first U.S. jetplane flew in Oct. 1942.



ELONGATED "SPIT"

Latest modification to Supermarine "Spitfire IX" series is pointed wingtip replacing conventional elliptical shape. Newest tips add approximately 4 ft. to original 36 ft. 10 in. span and have been designed for high altitude work, reportedly giving better than 2,000 ft. higher ceiling. Standard armament consists of two 20-mm. cannon and four .303-cal. machine guns. Other "Spitfire" modifications have included clipped wing version to improve performance at lower altitudes.

ON SCHEDULE . . . . . By "VISTA"

In London, recent U. S.-Britain meetings have aimed to range the field of postwar commercial aviation. And at press time, two results appeared to have been attained—an agreement that the Axis nations will not be permitted to operate commercial airlines for some time after the war (as predicted earlier by AVIATION), and a growing understanding that a satisfactory arrangement can only be expected through America and Britain meeting each other half way. A prelude to full United Nations' conferences late this year or early in '45, these talks found high British officials, including Lord Beaverbrook, discussing the air transport approaches with U. S. representatives Adolph Berle, Jr., of the State Department and Edward P. Warner of the CAB.

The preliminaries give some idea where the main argument will lie when all nations tackle the problems. Indications point to a limited "freedom of the air" policy along with certain restrictions on cut-throat competition through government subsidies, with overall control through an international body patterned after the I.A.T.A. At least an attempt is being made to arrive at some kind of agreeable set-up which will not damage national prestiges in the postwar commercial aviation field.

Some quarters feel that the several new British airliners now receiving publicity are being offered as "answers" to craft being developed on this side of the Atlantic. The plane outlined by the Brabazon committee (see accompanying story) can generally be considered as replying to such planes as the Douglas DC-7 of 150,000 lb., Consolidated's new Model 39 of 60,000 lb. and Model C-99 for 400 passengers, and Boeing's C-97, which according to British reports represents the commercial counterpart of the *Superfortress*.

New Gnome-Rhone Engine

Reports from inside France tell of development of a new multiple-row engine by Gnome-Rhone. A four-row engine with fan-assisted cooling, it is said to develop 3,700 hp. at 20,000 ft. However, the capacity is only 2,900 cu.in., and bore and stroke figures give the engine only 20 cyl., or four tandem-placed 5-cyl. engines. Until more complete reports are received, data on this engine must be considered questionable.

★INTERNATIONAL BRIEFS★

Postwar plans for Sweden's ABA call for extensions to Lisbon, Vienna, Scotland via Oslo, and Warsaw via Danzig.

The Germans are now using the Do-217M1 with DB-605 engines.

Hitler's reputedly "super" dive-bomber turned out to be the Heinkel He-219. Meantime this craft has been converted into a nightfighter—to meet current urgent needs.

A new model "Lancaster" is now in operation. Known as the Mark III, it has Merlin 28 engines and a new-type bombardier's window.

The "Daily Mail" reports "secret tests" in many British factories with "family" helicopters for postwar use.

Issued by Britain's Civil Aviation Dept. is a booklet setting forth a new principle to determine proper length for runways, together with new rules for unobstructed approaches (called "flightways") to new airports.

A BOAC "York" has made survey flights along the West African coast in connection with possible Latin American plans.

Ansett Airways, now operating in Australia, is reported ready to open service to the United States.

Last 10 seconds of a 1000 mile flight
No time in the flight of a huge transport plane is more important than the seconds-short landing period.
America's biggest planes are equipped with Aerols* to cushion landing shock and provide protection to plane, crew and cargo. Introduced when aviation was still in its infancy, Aerols are contributing substantially to aviation's progress—as planes grow in size, weight and speed, Aerols solve the landing problem for these aerial leviathans.
THE CLEVELAND PNEUMATIC TOOL CO.
AIRCRAFT DIVISION • CLEVELAND 5, OHIO
Also manufacturers of
Cleco pneumatic tools, Cle-Air shock absorbers for vehicles and Cleveland rock drills for mining and construction.
AEROLS*
*THE PNEUMATIC-HYDRAULIC (AIR-OIL) SHOCK ABSORBERS ON AIRCRAFT LANDING GEAR

United Aircraft Corp. reports sales of $733,590,668 in 1943, an increase of 41 percent over sales of $518,970,578 in 1942, while net earnings were $15,396,114 or $5.30 a common share against $17,096,841 or $5.95 a sare in 1942. Renegotiation of 1943 profits is not anticipated. Postwar reserves of $28,004,464 have been set up, including $4,107,193 charged to 1943 operations. Company shipments plus those of licensees and associated producers totaled nearly $2,000,000,000 last year. Net profit on sales was 1.6 percent, while current assets at the year-end were $206,050,684 against current liabilities of $120,711,245.

Northwest Airlines' new financing consists of 117,460 shares of stock, with shareholders offered one new share at $16 for each share held. This will give Northwest 352,380 shares outstanding out of an authorized issue of 600,000.

Douglas Aircraft Co. reports sales of $987,687,196 in 1943 against $489,781,984 in 1942. And net profit is put at $5,952,257 or $9.92 a share against $9,229,620 or $15.38 a share in 1942. Current assets were $163,464,275 against current liabilities of $128,025,548. No further renegotiation adjustments are anticipated, since contracts were of the fixed-fee type. A contingency reserve of $6,950,000 was set aside.

Glenn L. Martin Co. reports sales of $632,163,870 in 1943 against $337,556,000 in 1942, with net profit gaining to $12,437,583 or $11.15 a share from $6,658,809 or $6.01 a share in 1942. Last year's earnings are subject to renegotiation. A contingency reserve of $3,000,000 in 1942, pointed out Pres. Martin, was augmented by an additional $7,000,000 in 1943.

American Airlines, requesting CAB authority to purchase a 60 percent control of American Export Airlines, would pay $25 a share for 120,000 shares of the latter's treasury stock, or $3,000,000. American Airlines net profits in 1943 were $3,192,969 or $5.18 a share against $3,851,714 or $6.33 a share in 1942.

Dividends: With the declaration of a 50c. dividend by Lockheed Aircraft Corp., Pres. Robert Gross said that "the more Lockheed's experience in its war work broadens, the more apparent it is that the company's margin of profit probably will be less than in the past. This and other factors must be taken into consideration in determining future dividends." . . . McDonnell Aircraft Corp. paid a $1.50 dividend per share on Apr. 1 . . . Boeing disbursed $1 a share on Apr. 19 . . . Airplane Manufacture & Supply Co. paid 5c. a share on Apr. 30, while Consolidated Vultee will pay 50c. a common share on May 15.

Bell Aircraft reports net profit of $2,462,414 or $6.24 a share in 1943 against $1,711,583 or $4.80 a share in 1942. Sales were $232,134,000 against $121,863,227. A contingency reserve of $600,000 was established in 1943 compared with one of $1,200,000 in 1942.

Airline profits: United Air Lines reports net profits of $3,203,276 or $2.13 a share in 1943 against $2,134,356 in 1942 . . . Eastern Airlines reported $1,426,859 or $2.42 a share against $3,535,503 or $5.99 a share in 1942. An excess profits tax liability of $3,150,000 last year was mainly responsible for the drop in earnings. . . . Western Air Lines reported net profit of $90,194 in 1943 or 22c. a share against $693,703 or $1.69 a share in 1942 . . . Braniff Airways reports net profits of $611,000 or 61c. a share in 1943 against net profit of $512,882 in 1942.

Loans: Beech Aircraft Corp. has arranged a 30-month revolving credit of $50,000,000 with 36 banks. Under the arrangement, the government guarantees repayment of 90 percent of the loan. Funds may be obtained for use in war production or in event of cancellation of war contracts . . . Kellett Aircraft Corp. has negotiated a $2,000,000 V-loan for use in financing or terminating war contracts, according to Pres. W. Wallace Kellett. The new loan supercedes a $1,250,000 earlier credit . . . Douglas Aircraft reported bank loans of $12,000,000 in its Nov. 30, 1943 balance sheet, these loans being obtained from a $40,000,000 line of bank credit previously extended to the company.

Kellett Aircraft Corp. reports sales of $11,297,106 in 1943 compared with $5,267,170 in 1942, a gain of 114 percent. Net earnings were $48,739 or 11c. a share last year. Postwar reserves increased from $49,802 to $200,000 at the year-end.

Postwar Plans: Republic Aviation expects to broaden its postwar activities to the fields of commercial transportation and private flying, according to the annual report . . . Douglas Aircraft has four new products of "exceptional performance and promise under development." . . . Glenn L. Martin Co. expects to market "Marvinol", a chem-elastic plastic with the characteristics of rubber.

Square D Co. reports sales of $45,710,433 in 1943 against $34,300,202 in 1942.

Bellanca Aircraft Corp. reports sales of $6,222,492 last year compared with $3,855,072 in 1942.

ADDING IT UP . . . . By RAY HOADLEY

Man bites dog. Aircraft officials have been pessimistic so long regarding peacetime reconversion that it almost bordered on the sensational when Alfred Marchev, president of Republic, flatly said the other day that he didn't believe the readjustment period would be nearly as disastrous as it had been painted by some of the industry leaders. That's the view we have taken the last few months ourselves, hence we're mighty glad to have Mr. Marchev, also a few others like Fred Robinson of National Aviation, set forth similar views.

Long term planning. The Republic executive looks for a substantial military market after the war. Some of the military folk speaking off the record, have not been as optimistic. But we think aircraft investors can interpret the appointment of Rep. Clifton Woodrum of Virginia, to head the House postwar military policy planning, as a good omen for the future. As early as 1927, Woodrum was a strong advocate of "steady, orderly, and progressive strengthening" of Uncle Sam's air arm. Many others on his committee are supporters of an adequate peacetime air force. Some Air Force officers fear post-World War I aviation history will repeat itself. We don't think so.

Congress fumbles the ball. The first stage of after-war adjustment planning was successfully passed when Messrs. Baruch and Hancock issued a report that was acceptable to both industry and government officials—no small achievement. But since the ball was handed to Congress to translate the report into action little has happened. More than 25 bills on some phase of the matter have been dropped into the hopper, yet sentiment has not crystallized into an acceptable pattern, indeed several Congressional committees were still holding hearings as this was written. The George-Murray bill looks like the best bet for a starting point, but Congress will have to step on the gas if a completed bill is to be passed before the fall election.

Dismissal wage. Aircraft officials are glad this ticklish matter has come out in the open through a proposal in Congress to give two weeks pay to dismissed war workers upon termination. It's definitely a problem for the government, since aircraft concerns don't have the financial resources to cope with this situation. But spokesmen for the industry hope it will be considered as separate legislation rather than as an attachment to the main postwar adjustment bill, which would cause more delay.

A billion-dollar airline. Granted that we toss money around pretty freely these days, that billion dollar international airline proposal of Senator McCarran's looks super-colossal. It would mean that this "chosen instrument," picked to represent the United States abroad, would have seven times the capital of all our present commercial aviation companies. We wonder if the Senator wouldn't settle for a capitalization of, say, $500,000,000. Even then the government would have to put up most of the money.

Airline merger implications. When American Airlines recently took the bull by the horns and announced moves to acquire working control of American Export Airlines, a domestic air carrier thus got a foot in the door of transocean air commerce for the first time. Wall Street now looks for United Air Lines to make some sort of working agreement with Pan American Airways in order to offset this strategic American move.

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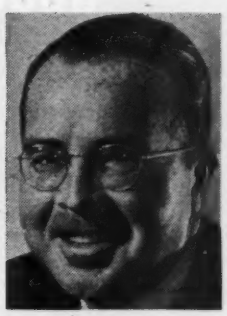
Aviation People

ALFRED B. BENNETT, noted aviation expert, flyer, and executive becomes director of post war sales for Aeronca Aircraft Corp. He was one of the foremost merchandisers of civilian aircraft before the war.

HARLAN P. HALLOCK has been appointed traffic supervisor in New York City for American Airlines. In his new post he will have supervision over representatives of passenger traffic, cargo, and publicity.

MARC THOMPSON, head of newly established CAA Airport Building Design Unit (see Transport News) is on a nationwide tour to gather information about present and future airport building trends. (CAA photo.)

SHEPARD DUDLEY has been named president of the newly formed Intava, Inc., formed by Standard Oil of N. J. and Socony-Vacuum to provide complete aviation service to U. S. airlines in their operations abroad.



ARTHUR FORISTALL, formerly director of public relations at Consolidated Vultee's San Diego division, has returned to duties at the N.Y.C. office of Hill & Knowlton, public relations counsel for the company.

WILLIAM A. M. BURDEN, new Assistant Secretary of Commerce, has been named Surplus Property Administrator. Mr. Burden originally entered Department of Commerce service in 1942 as special assistant to the Secretary of Commerce.

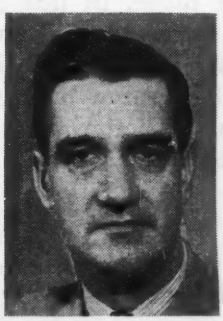
DR. STEVEN E. MAUTNER has been appointed executive vice-president and chief engineer of Skydyne, Inc. A pioneer in the sandwich type of monocoque construction, he worked with famous French designers before coming to the U. S.

COASTAS "GUS" PAPPAS, Republic Aviation engineer, was awarded the Wright Brothers Medal by the Society of Aeronautical Engineers for his presentation of the best paper on aerodynamics and structural research during 1943.

FREDERICK P. CULBERT, former American vice-consul at Casablanca and long-time French representative for UAC, was named general manager of Al-Fin Corp., was one time chief pilot at Navy lighter - than - air school. (Tommy Weber, photo.)

MILO G. BURCHAM, ranking test pilot and pioneer in high-altitude flight research, was named chief pilot, chge flight operations, Lockheed Aircraft Corp., will direct the test pilots and continue certain of his own test flying activities.

W. M. "BILL" MORGAN has been named special representative in Oklahoma for Braniff Airways. After serving on the aviation committee of the Oklahoma Chamber of Commerce for many years, he is now chairman of that committee.



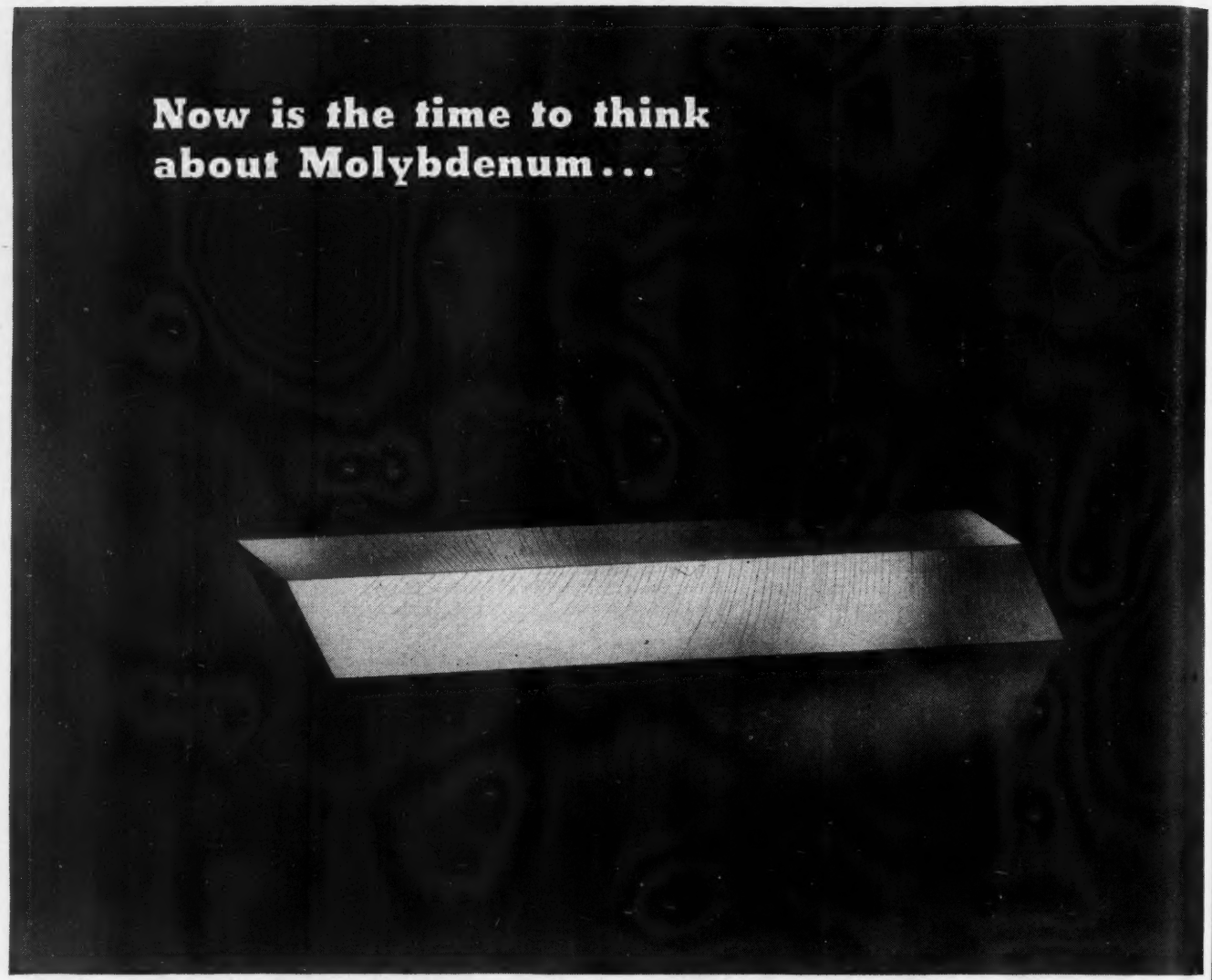
HOWARD W. CHENEY, former Lockheed Aircraft Corp. advertising and sales promotion manager, has been named assistant to Pres. R. S. Macmillan, of Macmillan Petroleum Corp., will be responsible for advertising and merchandising.

JOHN R. CONRAD is manager of the new properties division for Douglas Aircraft's Long Beach plant. Believed to be the first of its kind in the aircraft industry, the division is thus headed by one of the youngest executives in aviation.

MALCOLM Y. McCORMICK joined CAA's Medical Division to make an analysis of half million records of medical examinations of airplane pilots. A graduate in psychology of University of Maine he obtained his master's degree at N.Y.U.

CARL O. SAMUELSON has been appointed contracts manager of the Ranger Aircraft Engine Div., Fairchild Engine & Airplane Corp. Before joining Ranger, he was contracts manager for Lycoming Div. of The Aviation Corp.

Now is the time to think about Molybdenum...



Taylor and White's great discovery which made possible high speed cutting was the greatest single development to help make mass production possible. The steel developed, commonly known as 18-4-1, served industry faithfully for over thirty years without a serious competitor.

In the early 1930's the first molybdenum high speed steels were used on a substantial commercial basis and, before the Second World War, about 25% of all tungsten high speed steels had already been replaced by molybdenum high speed steels on merit. This steady progress of logical replacement of the tungsten steels was interrupted by the war because of the tungsten shortage, when many industrial plants were forced to a sudden change to molybdenum steels.

Because of the stress of war production many concerns have never had an opportunity to satisfy themselves thoroughly as to the comparative merits of the molybdenum high speed steels. For those, in this category, who are inclined to return to the tungsten steels, we suggest a serious consideration of the following facts—molybdenum high speed steels perform as well as, or better than, tungsten steels—and they cost less.

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Products and Practices

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ENGINEERING DATA

Lubricating Oil Tests.....1

Sinclair Refining Co., New York, offers 44-page booklet *Aircraft Engine Lubrication,* containing new altitude engine-performance chart showing problems of pressure, temperatures, and power loss requiring solution. Included are full-color charts of lubrication systems of aircraft engines.

Junction Boxes, Assemblies.....2

Released by Union Aircraft Products Corp., New York, is booklet *Quality Standards for Aluminum Junction Boxes & Assemblies.*

X-Ray Protection 3

Offered by Bar-Ray Products are blueprint, architectural drawings, specifications, and other information on building of X-ray rooms and departments, with special reference to protection of operators. Catalog deals with firm's lead products.

Fire Protection System.....4

How new "alneumatic" system for protection of aircraft in flight has been developed for use on larger and longer-range multi-engined planes of today and tomorrow is described and pictured in detail in brochure titled, *The Fire Extinguisher Takes Wings,* published by American-La-France-Foamite Corp., Elmira, N. Y.

Decimal Equivalent Charts.....5

Dayton Rogers Mfg. Co., Minneapolis, announces free distribution to engineering departments of framed decimal-equivalent charts with 13 x 18-in. glass protected table.

Flange Packings 6

Packings Pointers, edition No. 4, from Graton & Knight, Worcester, Mass., diagramatically illustrates uses, lists design features, and reviews case studies of flange packing.

Power of Research 7

B. F. Goodrich Co., Akron, offers reprint of a speech by Dr. Howard E. Fritz before Technology Club of Syracuse. Titled *The Power of American Research,* it points out growing importance of research in industry.

Fire Extinguishing 8

Booklet from Cardo Corp., Chicago, illustrates how five fire-hazard requirements are met in a single system. Included are typical performance data.

Adhesives 9

To meet aircraft requirements, more than 700 adhesives and sealers have been developed by Minnesota Mining & Mfg. Co., Detroit. Certain of these are described in new booklet, *3-M Adhesives in the Aircraft Industry,* which includes project sheets on which your problems may be listed and sent in. A second manual, *Scotch Adhesive Tapes,* is profusely illustrated and includes samples.

PRODUCTION

Induction Heating 10

Results With Tocco, publication issued by Ohio Crankshaft Co., Cleveland, is collection of case histories illustrating Tocco process and machines.

Piston Ring Rust.....11

Stating that air conditioning reduces rust to a minor problem in piston ring manufacturing, Carrier Corp., Syracuse, N. Y., offers advice and information.

New Packaging Material.....12

Goodyear Rubber Co., Akron, announces V-Film, a new packaging material with base of plastic resin. Though not a substitute for company's Pliofilm, it is an alternative in some applications. And though not equal of Pliofilm in some respects for moistureproof packings, it is stated to be superior in tear resistance and certain other factors.

Fastener Catalog 13

Catalog F, covering cap screws, set screws, aircraft bolts, nuts, etc., is announced by Cleveland Cap Screw Co., Cleveland.

Hole Punching 14

New catalog *PS* from Wales-Strippit Corp., N. Tonawanda, N. Y., illustrates and describes full line of plate sets, punch assemblies and dies, feed carriages and accessories.

Carbide Tools 15

Standard carbide tools and blanks are described in detail in new catalog from Kennametal, Inc., Latrobe, Pa.

V-Belts 16

B. F. Goodrich Co., Akron, introduces a wire grommet V-belt in a new folder. Belts are stated to have high tensile strength, high resiliency to resist shock, and to allow an increase in horsepower ratings.

Grinding Practice 17

Booklet of illustrations and text from Blanchard Machine Co., Cambridge, Mass., shows actual jobs on firm's grinders. Details concern material, stock dimensions, limits, quantity per hour, etc. Title is *Work Done On the Blanchard.*

Carbide Tipped Cutters.....18

Bulletin GT-17¼ from Carboloy Co., Detroit, details high speed milling of steel with carbide tipped cutters, and tells how, when required, a special cutter may be designed.

New Gage Catalog 19

Information on gaging practice and tables and charts on threads, etc., are found in new catalog issued by Republic Gage Co., Detroit.

Wirebound Boxes 20

From General Box Co., Chicago, comes manual of instruction on efficient handling of wirebound boxes.

Materials Handling Trucks.....21

Illustrations and information on "how" of materials handling, storing, etc., have been issued by Industrial Truck Statistical Assn., Chicago. Title of publication is *Unit Loads — Their Handling — Shipment —Storage.*

MACHINERY & ACCESSORIES

Electric Hand Tools.....22

Facts & Figures, booklet from Precise Products Co., Racine, Wis., describes high speed electric hand tools and what they do. Particularly treated are outstanding features of Precise 35, speed tool operating at 35,000 rpm.

Polishing Lathe 23

Engineering and data bulletin is now ready on magnetic polishing lathe offered by Lima Electric Motor Co. Detailed are principles and method of operation to show application of magnetic chuck as well as use of several types of face plate.

AVIATION READER'S SERVICE

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NAME..... TITLE.....

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AIRCRAFT

Aircraft Overhaul 24

Freed of some of its government work, Embry-Riddle Co., Miami, offers overhaul facilities to civilians. Pamphlet describes company departments: Engines, propellers, instruments, radio, parachutes, special projects, etc.

ELECTRICAL

Transformers 25

New method of attaching transformer cases designed to eliminate strain on solder seal has been developed by Thermador Elec. Mfg. Co., Los Angeles. Company states transformers are specially able to withstand shock and immersion.

Solderless Wiring Devices.....26

Large reference manual—*Catalog SD-1*—issued by Aircraft-Marine Products, Harrisburg, Pa., includes illustrated data on company's line of solderless insulation support terminals, standard and flag type terminals, connectors, lighting contacts, cable lugs, wiring plugs, standing and quick disconnect bonding jumpers, splicing terminals, grid clips, etc. Hand tools and installation presses are described, and there are instructions for setting up crimping dies. Data, specification, and dimensional charts on Army, Navy, and commercial wire sizes are given, and there are wire reference data.

Insulating Varnishes.....27

Sterling Varnish Co., Haysville, Pa., has published *Bulletin 243* concerning "Speedairbonds", air-drying varnishes for electrical insulation industry. Maker states features are fast drying; smooth and glossy finish; resistance to oil water, acids, and alkalis; and high dielectric qualities.

Current Interruptor 28

Bulletin 201-A issued by Sciaky Bros., Chicago, describes Dynatrol, new device for high speed, arc-less current interruption of inductive d.c. circuits, designed to replace magnetic contactors formerly used on resistance welders of electro-magnetic stored-energy type. Unit is available on all Sciaky welders up to and including 50 kw.

MANAGEMENT & EMPLOYEES

Valve Chart 29

For shop training or for a refresher on valves, new valve selection chart is offered by Reading-Pratt & Cady, Bridgeport, Conn. Of cardboard, chart explains conditions to consider when selecting a valve, also describes how these conditions affect operation of a valve.

Service Film 30

New training film *Installation, Maintenance & Service of Aircraft Pistons and Rings*, is offered no-charge for 10-day period by Ramsey Accessories Mfg. Corp., St. Louis. Film was produced at Wright Field by AAF technicians.

Fastener Stock Record.....31

In folder form, periodical record of various types and sizes of "in-stock" fasteners is offered by Manufacturers Screw Products, Co., Chicago. Among items treated are screws, washers, rivets, studs, nuts, and bolts.

Rubber in War.....32

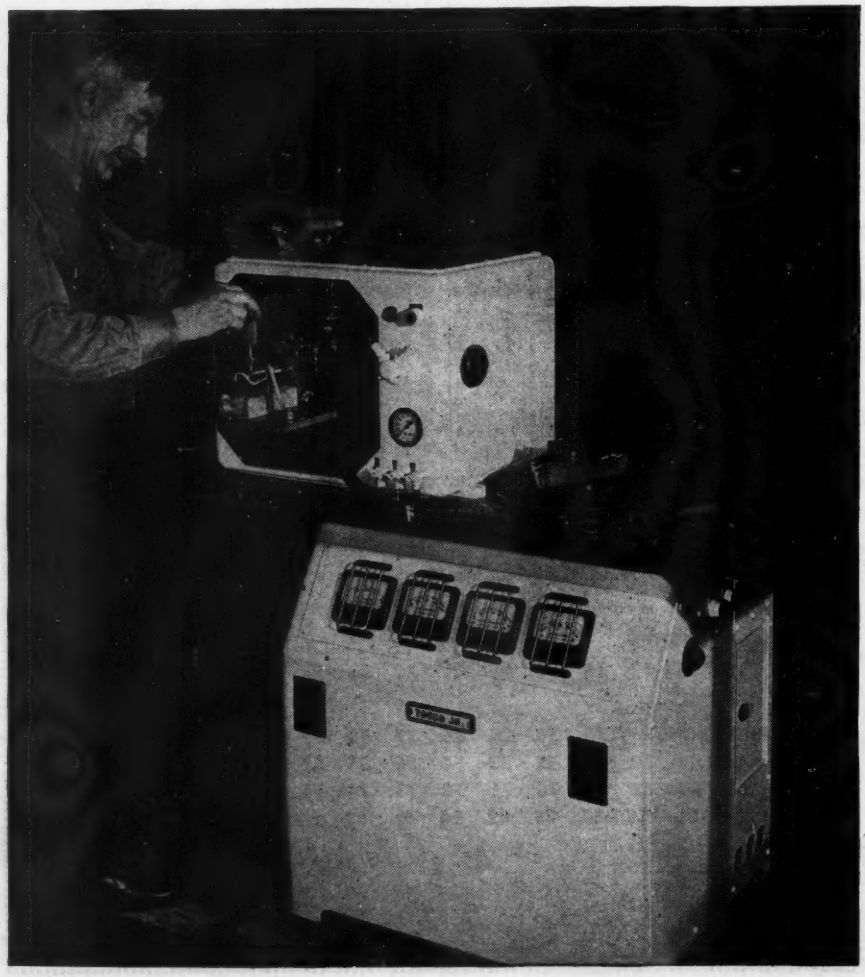
Eighty-page color booklet published by Rubber Manufacturers Assn., New York, illustrates and describes articles in which rubber is used in wartime and indicates why civilians should be content with less rubber and careful of that they have.

NEW PRODUCTS

Latest Machine Tools

Induction Heater 33

Work and power units are separate in 7½-kw. induction heating machine designed for annealing, heat forming, and hardening of small parts and for brazing carbide-tipped tools. Power (lower) unit is 30x36 in. and holds vertical 220/440-v., 3-phase, 60-cycle motor-generator set delivering 9,600 cycles; timer and field control switches are mounted on side of this cabinet. Work unit can be mounted on top of power cabinet or placed on a workbench (as in photo). It measures 20½x17x16⅜ in. and contains high frequency transformer, condensers, and panel for attaching work fixtures or indicator coils as well as quench valve, manifold, and gage for surface hardening. Quenching water can be delivered and returned through standard hose connections.—**AVIATION, May, '44.**



Parts Grinders 34

Small parts which require accurate grinding of parallel surfaces, such as washers, oil seals, sides of bearing races, piston rings, etc., can be ground at new high speeds, states **Chas. H. Besly & Co.**, Chicago, on company's grinders No. 253 (42-in. horizontal double spindle grinder) and No. 926 (double vertical spindle grinder). No. 253 rough- and semi-finishes work, while No. 926 is used for finishing pieces (to .0002 tolerance). Wide range of work can be ground on No. 253. Among fixtures are semi-automatic roll feed, semi-automatic rotary fixtures with multiple station solid or segmental feed wheels, power oscillating fixture, and hydraulic reciprocating planer type table mounted on base between grinding wheels. Unit is also equipped with vertical bar type wheel dresser and dresser bar. No. 926 is precision tool to finish-grind parts having an approximate equal area on parallel surfaces. Push button controlled wheel dressers, with adjustable diamond holders are furnished. Work feeding mechanism is semi-automatic magazine type with quick change endless feed chains. Multiple station rotary feed wheels mounted on vertical fixture spindle can also be furnished.—**AVIATION, May, '44.**

Hydromatic Milling Machine.....35

Accurately controlled milling of profile shapes is aim of Tracer Controlled Hydromatic line machines developed by **Cincinnati Milling Machine Co.**, Cincinnati. Units have same basic structure as regular line but are designed to provide sensitive tracer-controlled vertical movement of spindle carrier. Accurate duplication of master profile templates is obtained automatically, states maker, and automatic table cycles are synchronized with spindle carrier vertical movements. Tracer mechanism, mounted on spindle carrier, controls vertical position of carrier during cutting stroke of table. A roller on end of tracer valve mechanism engages master profile template. As table moves, roller moves along top of template; and vertical movements of tracer valve, imparted by roller, are duplicated

David and Goliath—Modern Version

BY JAMES M. SESSIONS

NO. 5 OF A SERIES "HIGHLIGHTS OF WORLD WAR II" PRESENTED BY TUBE TURNS (INC.) LOUISVILLE, KY. SEE OTHER SIDE

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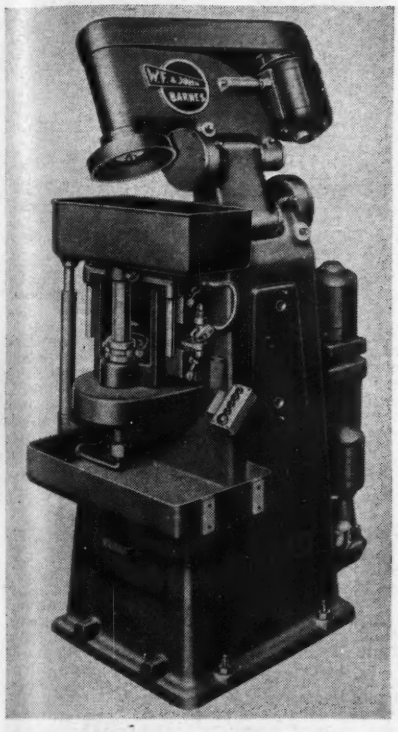
TUBE TURNS *Forgings for Industry*

Symbol of U. S. Navy combat courage against overwhelming odds (see reverse side) is Sessions 5th in a series of 12 unusual war paintings presented by Tube Turns.

in magnitude by spindle carrier. Table and carrier movements are auto-synchronized so spindle carrier will always be in uppermost, or retracted, position before table can move at rapid traverse rate and, conversely, in lowered, or cutting, position, with tracer roller engaging template, before table can move at feed rate. Selector valve provides for disengagement of tracer control and permits use of machine for heavy duty production work. Table feeds are hydraulic and infinitely variable—AVIATION, May,' 44.

Optical Lens Grinder 36

Now offered by **W. F. & John Barnes Co.**, Rockford, Ill., is Model No. 4 automatic grinder (optical curve generator). Incorporating use of diamond tools, it is equipped with special hydraulically actuated system for automatic cycle operation,



and maker states a semi-skilled operator can operate one or several machines. Proper curvature is obtained by two simple angular adjustments of top spindle arm plus a differential screw micro-adjustment incorporated in spindle. For single lens operation, machine is equipped with vacuum holding device where lenses having sufficient edge thickness can be chucked and held without use of pitch. Capacity: 8-in. dia. maximum size lens. Machine dimensions: 70 in. high, 24 in. wide, and 33 in. deep. Loading height is 48 in.—AVIATION, May, '44.

Milling Cutter 37

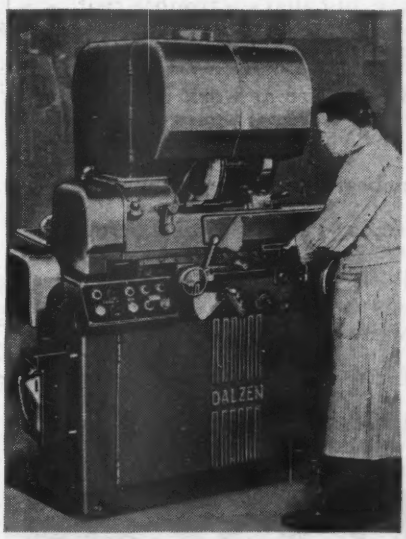
This unit, offered by **Detroit Tap & Tool Co.**, Detroit, is designed to cut straight sided threads at production speed. Cutter teeth engage work parallel to axis of threads being formed but rotate in a plane inclined to straight side of thread. Inclination of cutter at an angle equal to taper of cutter provides clearance for straight side cutting face to give even distribution of cutting load over full length of tooth face without tearing action. A plain milling section of cutter removes incomplete thread at outer edge. —AVIATION, May, '44.

Hydraulic Press.....38

One of largest hydraulic presses ever built for powder metallurgy is designed for briquetting powdered carbides of tungsten, titanium, or tantulum for carbide cutting tools, dies, and inspection gages. It is also suited to other powdered metal forming requiring application of high pressure from two points. Made by **Hydraulic Press Mfg. Co.**, Mt. Gilead, Ohio, presses may be designed to meet customers' particular requirements. One shown here will exert a downward pressure of 1,500 tons and a 1,000-ton force horizontally. Completely self contained, two H-P-M Hydro-Power radial hydraulic pumps are directly connected through flexible couplings to a 30 hp. double-end-shaft electric motor. H-P-M Fastraverse prefill valves provide direct communication between overhead oil tank and two pressure cylinders. As press rams advance, cylinders are filled with oil by gravity, eliminating need for large capacity pumps. Pump pressure quickly builds up as soon as rams meet resistance. Operation is automatic with push button starting and automatic predetermined pressure reversal. Downward acting ram has maximum travel of 18 in. and horizontal stroke is 6 in.—AVIATION, May, '44.

Thread Grinder 39

New type of thread grinder, electronically controlled by GE Thy-mo-control drive, is announced by **Dalzen Tool & Mfg. Co.**, Detroit. Aimed to provide highest production of threaded parts, advantages are claimed in control of work quality, ease of operation, and speed of uniform production. Speeds of work and grinding wheel are individually controlled by dial



settings. This variation is stepless and ratio of speeds infinite. Gear changing is stated to be reduced to a minimum. Motor elevation of head is designed to permit rapid clearing of work. There are two models: No. 5 universal for work up to 9¾ in. length of thread any place on 20-in. shaft; and No. 6 production without back-off feature for work up to full 20-in. length of thread on 20-in. shaft.—AVIATION, May, '44.

MANUFACTURERS

• Announcement of new machine tools and shop equipment and accessories are invited for inclusion in these columns. In writing, emphasis upon aviation industry applications of newly-marketed items is desirable, and, wherever possible, glossy-print photos should be enclosed for illustration. (Please do not send electros.) Manufacturers should address —

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Shop Equipment & Accessories

Aircraft Putty 40

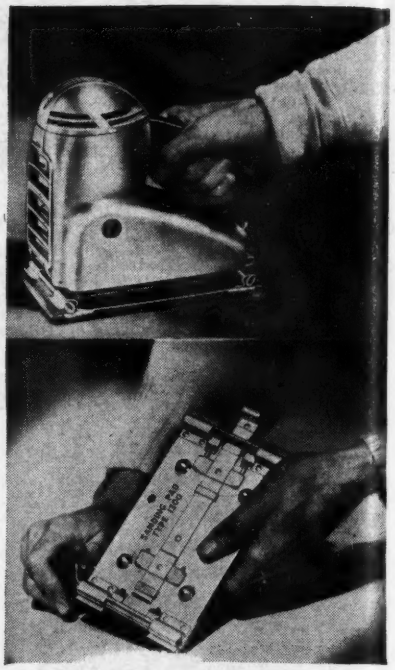
E. I. duPont de Nemoirs & Co., Wilmington, Del., announces that its Finishes Div., Parlin, N. J., has developed flexible, high-adhesion aircraft putty for filling dents and cracks between riveted aluminum sheets forming aircraft wings. Product is listed as No. 228-711. Of buttery consistency, it is stated to be fast drying, low in shrinkage, and of minimum weight.—**AVIATION, May, '44.**

Jig Saw 41

Announced is new jig saw offered by **Boice-Crane Co.**, Toledo, Ohio—unit with universal full-duty blade chucks that take blades from 5 to 9-in. long and also die files. For heavy-duty sawing and sanding of metals, woods, and plastics, unit measures 24x5 in. Cast iron work table is 20-20 in. When upper head is turned, states company, blade-guide, blower, and hold-down all follow around as one unit. —**AVIATION, May, '44.**

Portable Sander 42

Outstanding feature of Sterling 1000, sander offered by **Sterling Tool Products Co.**, Chicago, is flexible sanding pad which detaches by pulling out latch. Loaded pads can be kept near work and



changes made quickly. Unit is designed to provide fast, uniform cutting on wood, metal, and plastic, and is stated suitable for everything from coarse sanding to lapping and finishing. Flexible pad will conform to moderate curvatures, while special pads for unusual contours are available for those manufacturers desiring them.—**AVIATION, May, '44.**

Discharge Circuit Resistors 43

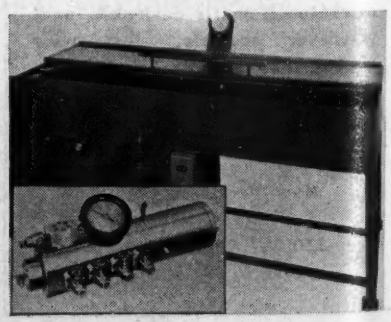
Announced by **Sprague Specialities Co.**, North Adams, Mass., are Meg-O-Max resistors for high resistance value units for operation at high voltages and ambient temperatures, also for dissipating power. Resistors are available in two lengths: Type 1, 5 9/32-in. long, with range of 3,600 ohms to 100 megohms; and Type 2, 9 25/32-in. long, with range from 6,800 ohms to 100 megohms. Units are formed of series of pressed and sintered ring-shaped segments electrically joined for non-induction. Finished resistors are encased in hermetically sealed glass envelope provided with ferrule terminals.—**AVIATION, May, '44.**

Camouflage Remover 44

Offered by **Kelite Products**, Los Angeles, for camouflage removal, is KDL No. 32, new cold stripper applied by spraying or brushing. Paint removal can be completed by hosing with water.—**AVIATION, May, '44.**

Hydraulic Test Bench 45

Model T-113, by **Hydraulic Machinery**, Dearborn, Mich., includes intensifier for developing up to 30,000 psi. Hydraulic circuit consists of a 2,000-psi. constant delivery pump (approx. delivery 2 gpm.) directly connected to manifold incorporated in high pressure intensifier hydraulically operated with 15-to-1 ratio. Re-



MAKE TIME
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"YANKEE" TOOLS!

Do the tools you buy make your work easier, faster, more efficient? Do they save you time, money, trouble? Will they stand the pressure of hard work, earning their keep by long, dependable service? They will, indeed, if they are "Yankee" Fine Mechanics' Tools, the choice of true craftsmen everywhere, for more than half a century. There's only one trouble with "Yankee" Tools today, but that's a trouble that will be corrected quickly by Victory: Supply can't keep up with demand . . . for "Yankee" Tools, you see, are at work for war. So remember the built-in ingenuity of "Yankee" Screw Drivers, Drills, Vises, Bit-Braces, and Tap Wrenches. They've been *designed* to make time! And making time, above, is "Yankee" Spiral Screw Driver No. 130A — a size for every purpose.

Order from your supply house, or write North Bros. Mfg. Co., Dept. AV-544, Phila., Pa. Furnish priority ratings whenever possible, and every effort will be made to fill your orders.

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Established 1880

ported features of pictured "HY-MAC" model: High pressure connections, balanced high pressure plunger and packless plunger sealing, extreme pressure inlet check valve for charging high pressure cylinder, multiple in-line high pressure connections for burst testing (four tubes or other parts simultaneously), high pressure gage and pressure release connections and "O" ring type packing on low pressure piston. Rolling Plexiglas top protects operator when making burst tests. Dimensions: 37 in. wide; 41½ in. high; and 96 in. long. Intensifier is 30 in. x 9 in.—**AVIATION, May, '44.**

Clamp for Small Work 46

Parlec clamp, announced by **Earl C. Parkhurst,** Inglewood, Calif., is for holding small work together in tapping, drilling, etc. Device consists of two case-hardened steel jaws, two case-hardened steel adjustment nuts, and two heat-treated steel studs. Studs are fastened solidly to lower jaw, and one adjustment nut is screwed on rear stud. Upper jaw is slid into place on studs and other nut screwed into place on front stud. Thus top jaw is movably controlled by two nuts, front nut acting as a pivot and rear nut exerting gripping pressure. Tightening torque is positive. Model C-15 opens to 5¼ in. with jaw length of 6¼ in., while Model C-20 opens to 6½ in. with jaw length of 7¾ in. Special sizes, however, may be ordered.—**AVIATION, May, '44.**

Carbide Tipped Tools 47

A new line of standard carbide tipped tools in six shank and tip styles is announced by **New England Carbide Tool Co.,** Cambridge, Mass. Tips are finish-ground on diamond wheels to give exposed surfaces mirror finish. Two grades are supplied.—**AVIATION, May, '44.**

Angle Drill 48

Lighter in weight because of die-cast body, new drill brought out by **Zephyr Mfg. Co.,** Inglewood, Calif., has large-area, replaceable, oil-less bearings. Drive shaft is precision ground, and gears are

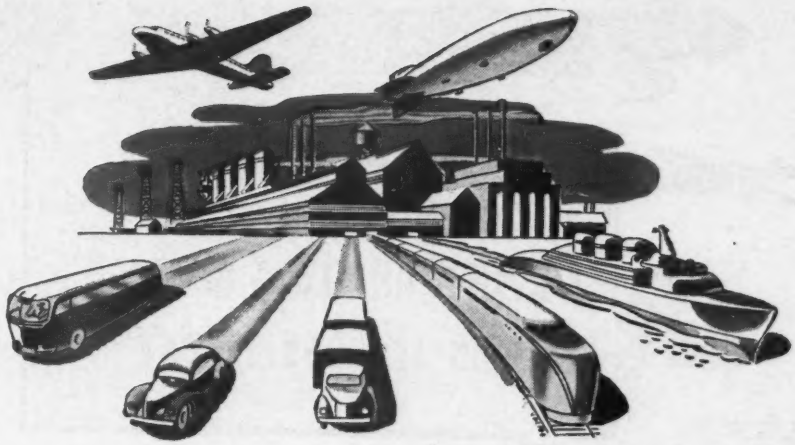
heat treated. Steel snap-on guard provides protection. Spindle offset is 7/32 in. and spindle thread ¼-28.—**AVIATION, May, '44.**

Control Disconnector 49

Device called "Potter Disconnect" is for quickly disconnecting push-pull, torque tube, or cable controls. It is stated to separate any control rod, tube, or cable simply by depressing a spring with an integral knurled sleeve. Control is connected by placing two ends of device together and permitting beryllium-copper coil to spring into place. Three sizes—⅜, ½, or ¾ in.—are offered by **Otto Aviation Co.,** Bloomfield, N. J.—**AVIATION, May, '44.**

Air-Line Water Eliminator 50

Unit designed to eliminate water in air lines, is offered by **Inco Engineering Co.,** Cedar Rapids, Iowa. Described as air-strainer with trap, it operates on principle of high velocity impingement on cold surfaces in three stages for removal of moisture and oil. It is installed in air supply line nearest air grinders and air tools. Water exhaust valves are provided to relieve trapped water.—**AVIATION, May, '44.**



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FLUID POWER. Confine fluid in a closed system, apply power at one end, and you deliver power instantly at the other end.

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FLUID POWER ENGINEERING. That's been Parker's business for twenty years—designing Fluid Power tubing systems, engineering them, building valves and fittings, and making fabricating tools. Often we do the fabricating, too.

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LOOKING AHEAD. With at least one eye on the future, wouldn't you like to talk this through now with a Parker engineer? No matter what you make, or what kind of machines you operate, you are likely to find some interesting possibilities in the Fluid Power idea. An interesting booklet, giving you more facts about Fluid Power, will be sent on request. Address Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

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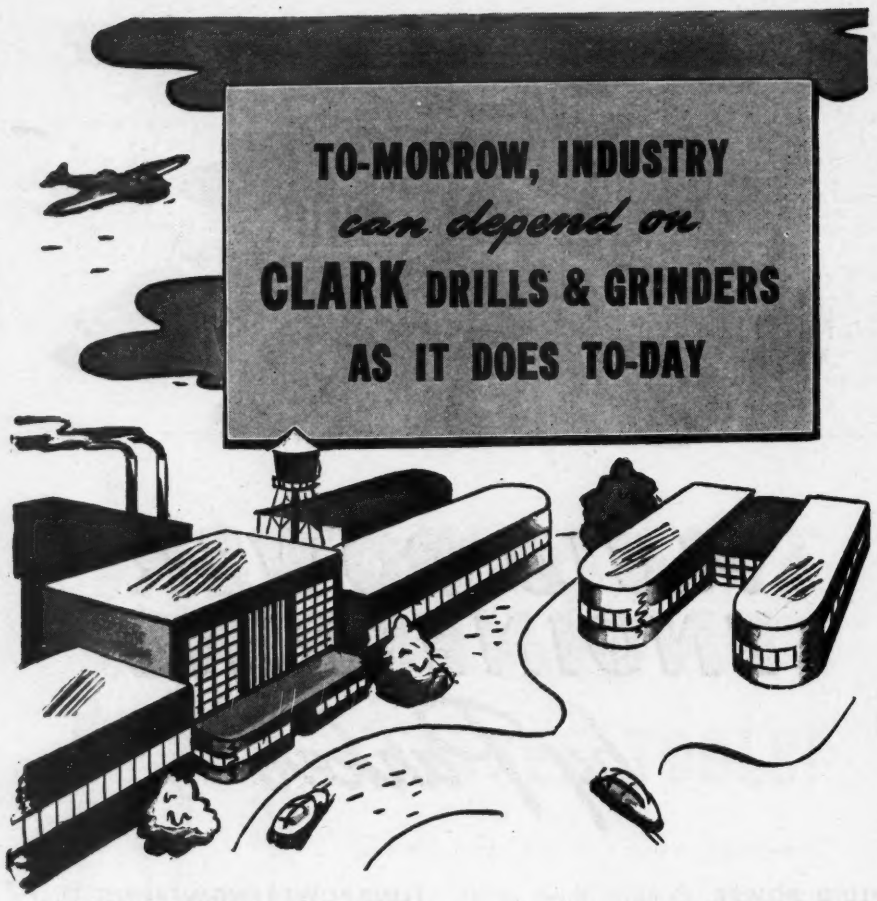
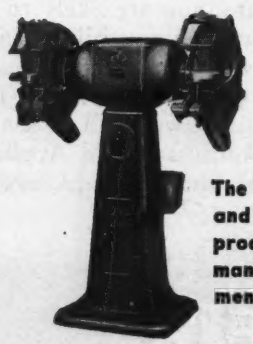


Ever since James Clark built the first electric drill over 50 years ago, the James Clark Jr. Electric Company has been first with all major improvements and innovations in these tools.

Present demands for production have called for greater efficiency and longer life for all types of machinery. Clark has so improved its electric tools that they have become known as the "work horses" of industry. Their greater efficiency and longer life have been outstanding.

Tomorrow, in the post-war era, Clark's portable drills and grinders will be available to all industry.

In your post-war planning, include these electric tools. James Clark Jr. Electric Company builds a wide range of sizes and models and has the tool that will fit any job. Look to this company for the finest in portable drills and grinders.



The James Clark Jr. Grinders and Drills shown are speeding production in war plants that manufacture vital war equipment.

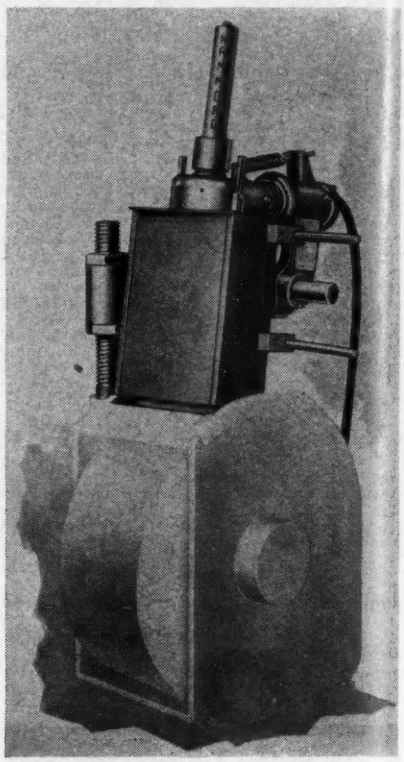
"first in the field" CLARK Electric Tools

JAS. CLARK, JR. ELECTRIC CO.

612 BERGMAN ST., LOUISVILLE, KY.

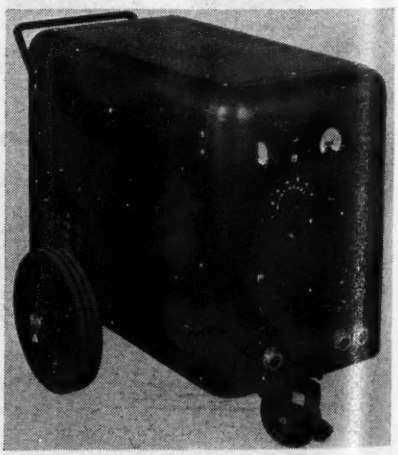
Composition Applicator 51

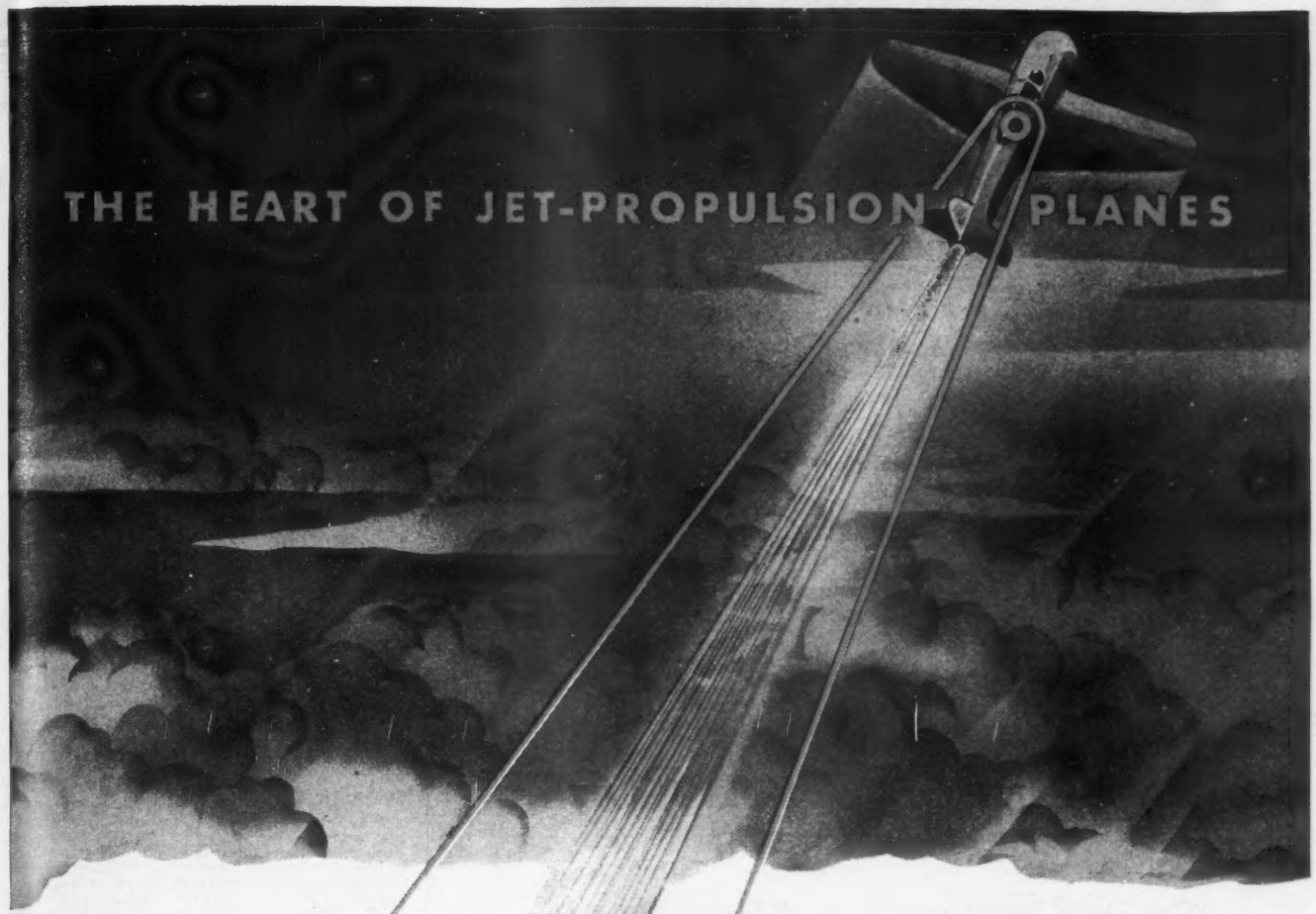
"Auto-Doper", an automatic air-operated cylindrical and rectangular composition applicator for use on any type polishing and buffing machine, is announced by **Hammond Machinery Builders,** Kalamazoo, Mich. It can be used for either cylindrical or rectangular bars by changing composition housing. Operated by compressed air, frequency of operation is controlled by air valve operated from cam, electrical timer, or foot valve. Unit as pictured is for 12-in. max. width by 2-in. thick by 10-in. long rectangular composition bars. Device for cylindrical composition bars takes work up to 2¾-in. dia. and 10 in. long.—**AVIATION, May, '44.**



Engine Starter 52

The Mallory Rectostarter, offered in portable or stationary models, is designed for starting aircraft engines, also as a d. c. power source for operating plane lights, radio and instruments while the craft is on the ground, and for testing. Supplies 12 or 24-v. d. c. with high surge for starting, and in continuous operation it is rated at 100 amp. at 24 v. or 200 amp. at 12 v. Operates from 208-230-v. a. c. 3-phase circuits, or 460-v. a. c. 3-phase circuits. Maker is **P. R. Mallory & Co.,** Indianapolis.—**AVIATION, May, '44.**





IS MADE OF SPECIAL TIMKEN ALLOY STEEL

A new Alloy Steel created by Timken metallurgists and introduced by the General Electric Company in their Turbosupercharger now plays a vital part in the G-E Jet-Propulsion Motor.

This new steel is tough. It's a steel able to resist the terrific heat created by hot gases passing through the vanes of the turbine wheel and also the tremendous centrifugal force developed in the wheel while spinning madly at thousands of revolutions per minute. Ordinary alloy steels would disintegrate if subjected to these gruelling demands.

In addition, this new Timken Alloy Steel has excellent weldability, good machinability, and high resistance to scale and corrosion at operating conditions. An impressive list of qualities, but everyone of them necessary to provide a practical jet propulsion power plant.

The big part Timken Alloy Steels have played in the past and are now playing in the war, emphasizes the promise that they will be of steadily increasing value in peace. Steel and Tube Division, The Timken Roller Bearing Company, Canton 6, Ohio.

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ALLOY STEELS

ANOTHER

Fastening Problem Solved!

THE ROSÁN MOLDED-IN

REPLACEABLE INSERT

When Clarke Aero-Hydraulics, Inc., of Pasadena, started to manufacture handles for Gun Turret Control Valves, they foresaw possible damage in field service and wisely made provision for quick repairs to the steel fastening points which were molded in the plastic handles. They specified the Rosán Replaceable Molded-In Insert, the only one which can be removed and replaced without disturbing the parent material.

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ARMY E NAVY

ROSÁN LOCKING SYSTEM

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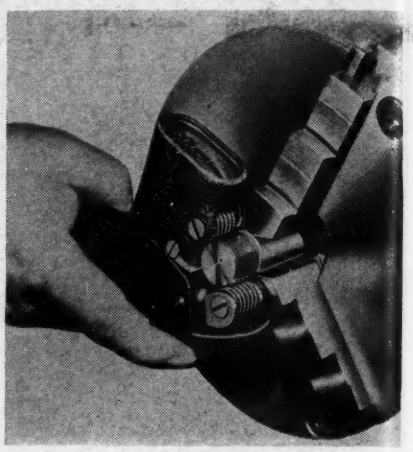
Dept. 3-54, Box 1310, Hollywood 28, Calif.

Roll Snap Gage 53

Limitrol, new snap gage, is of comparator type, with dial indicator gage. Designed for use as hand or bench type gage made by **N. A. Woodworth Co.**, Detroit, is stated to perform six inspection operations in one—that is, checks of



pitch diameter, lead, taper, angle, straightness, and out-of-roundness. It is made in six nominal sizes and is adjustable ⅛ in. either way. Thread diameters from #6 to 1 in. can be gaged. Rolls are provided in three widths: ¾, ⅝, and 1 in. Photo shows gage used as hand model.—**AVIATION, May, '44.**

Synthetic Cut-Off Disks 54

New Radiac synthetic disks and grinding wheels, made by **A. P. de Sanno & Son,** Phoenixville, Pa., are offered in place of scarce crude rubber products. Reported features are long life for fast, free cutting, giving excellent finish and little burn. Made in standard range of thicknesses and diameters up to 20 in., they are stated to show effective performance on wet grinding of ball bearing races and roller bearings.—**AVIATION, May, '44.**

Temperature Control 55

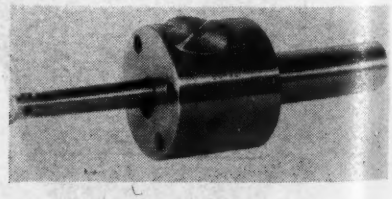
Named "Chronotrol," new instrument produced by **Wheelco Instruments Co.,** Chicago, has been developed to enforce any desired heating or cooling program through providing completely automatic regulation, regardless of charges in temperature desired, for any given process. Desired cycle is cut on a disk, and latter's rotation by synchronous motor moves setting lever of instrument. Unit is offered in 25 models.—**AVIATION, May, '44.**

Pressure Switch 56

New type pressure switch, with ranges from 5 to 5,000 lb., is equipped with direct action gage for hydraulic pressures operating sensitive electric switch. Size: 10x7x3 in. Maker is **Hercules Elec. & Mfg. Co.,** Brooklyn.—**AVIATION, May, '44.**

Boring Head 57

Borset, dial-set adjustable boring head for use in screw and milling machines, is announced by **L. H. Harvey Associates,** Minneapolis. Adjustable by means of large 1¼-in. dial calibrated in 25 divisions of .001 in., without removing tool,



it is designed to speed production and reduce set-up time. Available in two sizes: No. 1 for bores of from ½ in. to 1¾ in.; No. 2 from ½ in. to 2¾ in.—**AVIATION, May, '44.**

Circular Slide Rule.....58

Tavella Sales Co., New York City, offers 6-in. dia. "Monitor" slide rule made of white Vinylite. This circular rule is reported accurate within 0.5 percent. Scale length is 13.8 in.—**AVIATION, May, '44.**

Bag Sealing Compound.....59

Non-hardening sealer has been developed for added waterproof protection for export case liners and bags. Product sets up a bond between folds and is pliable to withstand shock and twisting. It withstands temperatures from —30 deg. F. to 200 deg. F., states maker, **Witco Chemical Co.,** New York.—**AVIATION, May, '44.**

Aromatic Solvent.....60

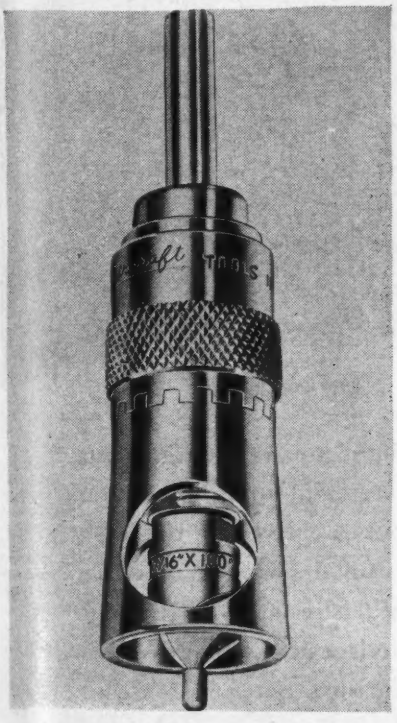
New alkyl aromatic solvent for use in metal-washing machines is non-inflammable and non-combustible, has no low volatiles, and forms sparkling clear solutions with water, states manufacturer, **Curran Corp.,** Malden, Mass.—**AVIATION, May, '44.**

Double-Action Calipers.....61

Modern Caliper & Tool Works, Chicago, announce combination calipers for both inside and outside measurements. Double unit comes in 3-in. and 6-in. sizes.—**AVIATION, May, '44.**

New Countersink.....62

Micro-set stop countersink, marketed by **Aircraft Tools,** Los Angeles, has few parts. It features split collet type shaft to allow use of various cutters and



pilots, full ball thrust bearing, positive sight adjustment in increments of .002 in., lock spring in sight adjusting sleeve, and pin that locks stop collar to shaft. Spring loaded spindle retracts cutter back into stop cage for safety.—**AVIATION, May, '44.**

Etcher and Demagnetizer.....63

Combination unit for etching and demagnetizing small tools, parts, etc., provides 14 heats, giving wide range from small, delicate parts to large castings. There is two-position switch for demagnetizing. Maximum rating is 5.5 amp., and over-all pole area is 13½ sq. in. Specifications: overall dimensions 8¼x11½x8⅝ in.; size of work plate 8¾x7¾ in.; weight 39 lb. Manufacturer is **Ideal Commutator Dresser Co.,** Sycamore, Ill.—**AVIATION, May, '44.**

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ANODEX Especially developed compounds for use with the *original* ANODEX reverse current electro-cleaning process for fast, positive cleaning of ferrous metals.

METEX Individually formulated compounds for precision cleaning. Now available in special variations developed for aviation problems.

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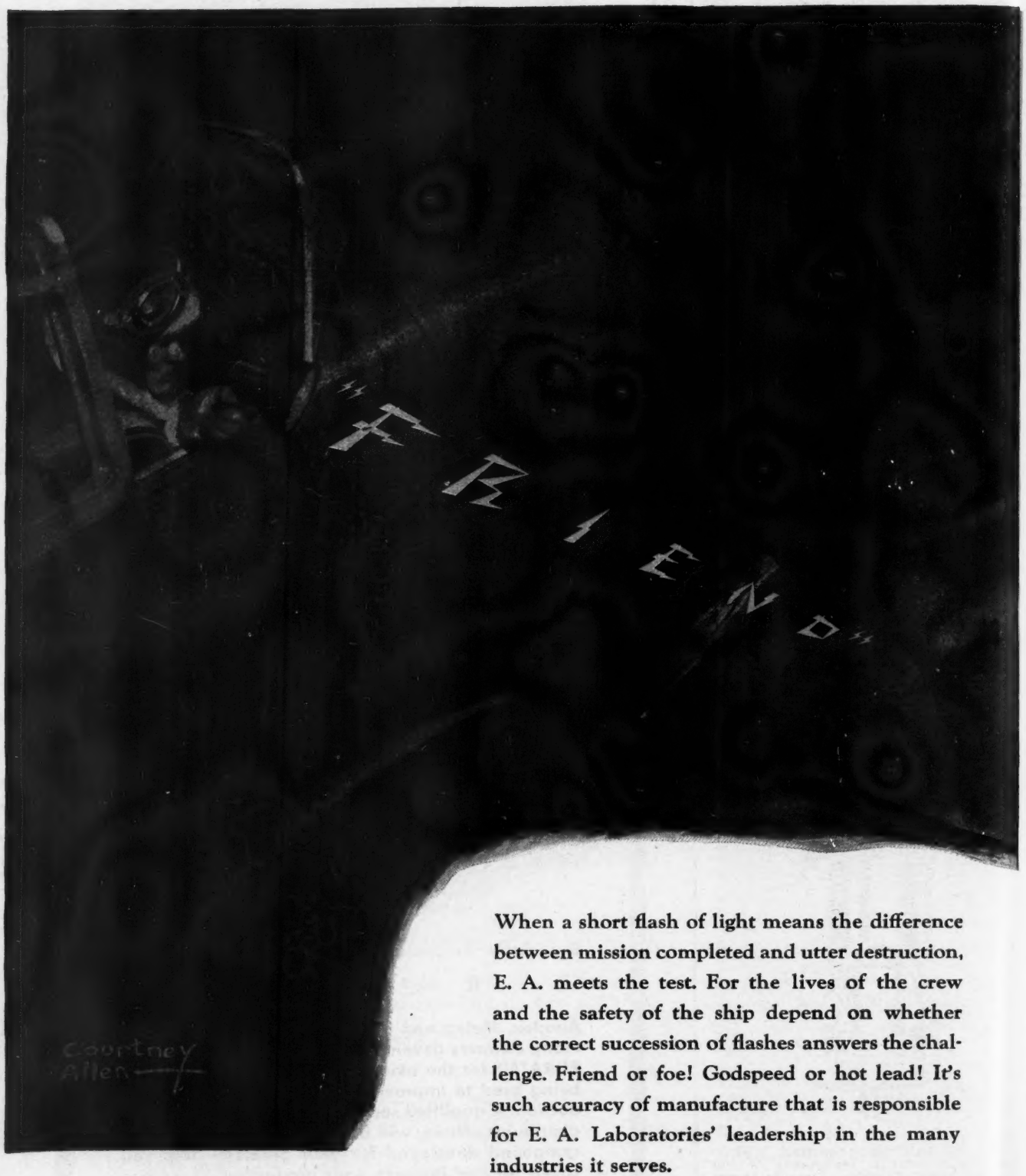

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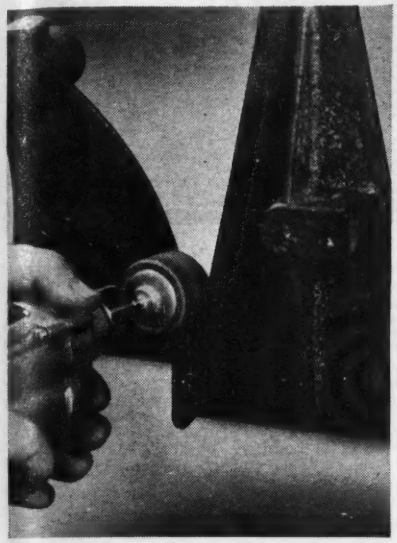
Grinding Bands 64

Fitted over rubber mandrels of suitable size, Three-M-ite cloth "Evenrun" bands, made by **Minnesota Mining & Mfg. Co.**, St. Paul, Minn., are designed to expedite individual finishing jobs on small and



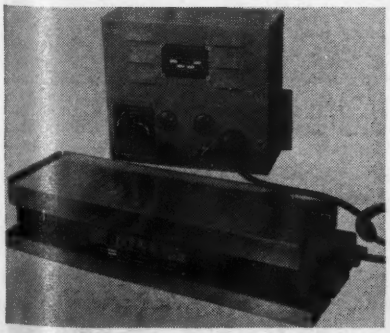
intricate pieces. Described as fast cutting and long wearing, bands are available in three sizes, ranging from 3/32 in. to 8 in. and with face width of ½ to 3 in.—**AVIATION, May, '44.**

Relay Set 65

Sensitive SS-5 relay set is announced by **H-B Instrument Co.**, Philadelphia. Unit is used with company's Red-Top thermo-regulator, also in conjunction with galvanometers, contact-equipped meters, gages, or other relay-operating instruments requiring low-gram contact pressure. Set consists of sensitive iron-core-magnet type relay (operating on 110 v. and 2 milliamps), and a solenoid-type mercury-plunger relay, the tube handling a load up to 30 amp. at 110-v. a. c. or 20 amp. at 220 v. Two relays are mounted side-by-side in hinge-covered housing, 5¾-in. wide, 5¼-in. high, 3½-in. deep. —**AVIATION, May, '44.**

For Difficult Grinding 66

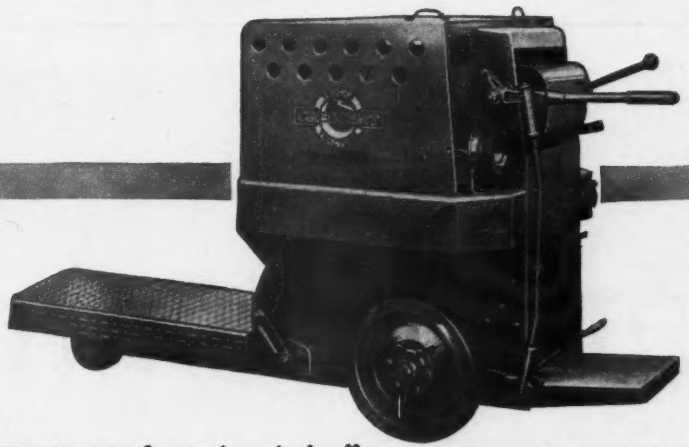
Two new related products.—DoAll electro-magnetic chuck and the "Selectron," aimed to improve and ease difficult grinding operations—have been developed by **Continental Machines**, Minneapolis. Through use of devices, states maker, amount of magnetic pull of chuck is under control of operator. Selectron employs electronic power to control flow of magnetic pull and to demagnetize chuck. Insulation is incorporated to prolong life of electric circuit and to conduct heat generated by coils to outer surface, where



it is dissipated to eliminate distortion of chuck surface. Chuck is watertight. Chucks are available in sizes 6x18 at 125 w. and 8x24 at 175 w. Both may be operated with 110v. d.c. or 220 v. d.c. In surface grinding, operator has variable control of current.—**AVIATION, May, '44.**

PREPARE TO COMPETE . . .

Plan ELECTRIFIED Materials Handling!



"THERE'S A BIG future in aviation" —sure, but don't forget, it's going to be a *competitive* future.

Be ready with the most efficient production system you can plan—*including electrified materials handling*. Because that's the kind of materials handling you'll compete with! Old fashioned methods will be . . . and already are . . . as outmoded as pre-war biplanes.

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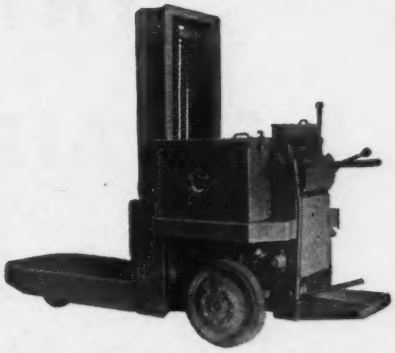
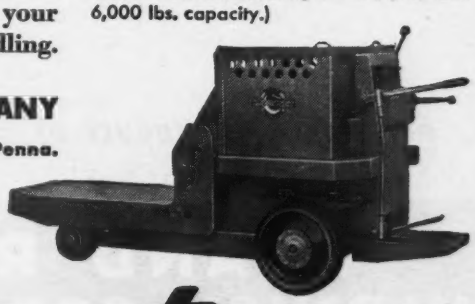
LO-LIF-TOER (LDLF)—Foot Lift Elevating Platform Truck. (3,000 lbs. capacity.)



NCRE—High Lift or Tiering Truck. (4,000 and 6,000 lbs. capacity.)

NDRE—Low Lift Elevating Truck. (4,000 and 6,000 lbs. capacity.)



Crescent ELECTRIC TRUCKS and TRACTORS

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Pneumatic Jaw 67

Hufford pneumatic jaw, a positive-opening-closing unit for holding work-piece during stretch-forming operations on Hufford beveling machine, comprises double acting integral air valve, piston assembly, housing, collar, and hardened steel jaw inserts. Valve operates via regular air supply. Air pressure against back of piston thrusts jaw forward to grip work solidly. Reverse stroke of piston releases work. Because of force generated, no "freezing" is possible, states maker, **Hufford Machine Works,** Redondo Beach, Calif.—**AVIATION, May, '44.**

Blackout-Paint Stripper 68

Primarily for removal of blackout paints of both asphaltic and non-asphaltic types, "Re-Lite" is ready-to-use product. Of heavy body, it clings without runs and is fast acting even on paint which has baked on light globes, states maker, **Turco Products,** Los Angeles. It is further reported that it will not attack concrete, brick, mortar, stone, tile, or marble, and that it has good penetration and cleaning power on porous materials, with cold water rinsing it completely.—**AVIATION, May, '44.**

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CONTINUOUSLY SUPPLYING FINISHES TO WRIGHT FIELD SINCE 1935.

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Paper Toughener 69

New synthetic resin, development of **Resinous Products & Chemical Co.,** Philadelphia, is designed to make paper tough enough to withstand rain, mud, and snow. Treated paper is now used for guards to protect heavy aerial bombs; many industrial applications are foreseen.—**AVIATION, May, '44.**

Casting Resin 70

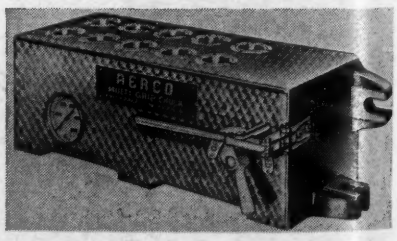
Produced by **Adhere, Inc.,** Los Angeles, Toolite casting resin is described as light and tough, with compressive strength up to 20,000 psi., and ability to "take" temperature of 400 deg. F. It is stated to be applicable in wide ariety of production tools, including structural parts of radial drills.—**AVIATION, May, '44.**

Wire Wound Resistors 71

Elco Resistors Co., N. Y. C., offers wire wound resistors in four sizes: "A", 15/32 long by ½-in. dia., 1 to 300,000 ohms; "B", 15/16 long by 12-in. dia., 1 to 500,000 ohms; "T", 1 1/32 long by 7/16-in. dia., 35 to 35,000 ohms; and "M", 1 13/32 long by ¾-in. dia., 1 meg ohm.—**AVIATION, May, '44.**

Multi-Grip Chuck 72

A new hydraulic multi-grip milling machine chuck is announced by the **Aerco Corp.,** Hollydale, Calif. New chuck has two rows of five collets, and since both rows of parts held in collets may be milled simultaneously, ten parts may be milled with one loading. Maker states that a few strokes of hydraulic pump (shown mounted on front of chuck), supplies pressure for closing all collets simultaneously, building up pressure to as much as 2,500 psi to hold work rigidly in collets. An adjustable depth stop, provided for each collet is designed to make it possible for operator to quickly insert pieces to be milled and at exact amount without use of gages. Chuck is available in two models, with pump, valves, pressure gage, depth gage, and collet assemblies all incorporated in main body of chuck itself. One size, 14¼x4½ x4½ in., has collet capacity of ⅛ to ½ in.; other, measuring 21x6¾x6¾ in., takes



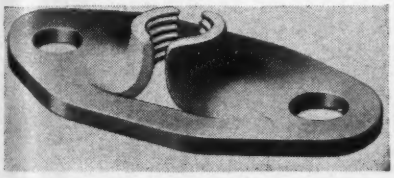
collets from ⅛ to 1¼ in. Round, square and hexagon collets are available for both chuck models.—**AVIATION, May, '44.**

Toolmaker's Wiggler.....73

Three interchangeable shafts are designed to assure precision set-ups with increased speed and accuracy in wiggler devised by **Nork Products Co.**, Los Angeles. Ball shaft is used for indicating from ground or machined surfaces and from gage blocks, also from side of round bars. In use, ball is first made to run true by holding any blunt object against it while spindle is turning, then it is coated with layout blue. Work is then fed toward ball until blue is barely wiped. Table is next lowered and moved .125 in. —half diameter of ball—to bring reference under spindle center. Subsequently, by using micrometer collar on lead screw, any desired distance can be located. Bent shaft is designed to hold any type indicator. Needle point shaft is used to find centers and to true-out layout lines. Spring chuck holds shafts.—**AVIATION, May, '44.**

Aircraft Nut.....74

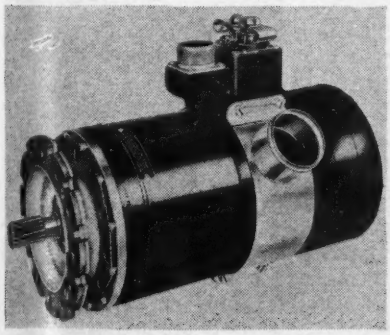
Unusually low installation torque allowing speedier operation is reported by maker, **Tinnerman Products**, Cleveland, for new light, one-piece-integral "Hi-



Stress" Speed Nut, which is interchangeable with nut plate AN 362 for high temperature applications. Self-locking torque of nut is said to be retained after many removals.—**AVIATION, May, '44.**

A.C.-D.C. Power Supply.....75

New Eclipse power supply systems, by Eclipse-Pioneer Div., **Bendix Aviation Corp.**, Teterboro, N. J., consist of engine-driven generators and carbon pile voltage regulators for both a. c. and d. c. outputs. Designed to mount on main engine generator drive pads of aircraft, they are fitted for generator blast cooling. Incorporated are 6-in. round flanges with 12 25/64 in. holes, 5-in. bolt circle diameter, 4.122-in. pilot dia., and a 16-tooth involute male drive spline. Available capacities: 60 to 20 amp. at 28.5-v. d. c. and 10.4 to 30.5 amp. at 115-v. a. c. Both a. c. and d. c. rated outputs are available



simultaneously, states maker, offering weight saving advantages. Rotating field inductors are to permit use of stationary a. c. windings, and d. c. outputs of more than one a. c.-d. c. generator can be paralleled. Regulation without fluctuation and minimum radio interference are reported.—**AVIATION, May, '44.**

Miniature Tube Socket.....76

Radio tube socket offered by **Hugh H. Eby**, Philadelphia, has silver plated, "micro-processed" beryllium copper contact stated to give higher electrical conductivity and low contact resistance between socket and tube pin. In low loss and general purpose types, sockets are designed to withstand humidity cycle, immersion, and vibration, and thermal shock.—**AVIATION, May, '44.**

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No. ZT. 21
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No. ZT. 47
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Swivel head
Light duty

No. ZT. 44
45° ANGLE DRILL
Oilless bearings

No. ZT. 19
90° STANDARD DUTY
Ball bearing spindle

No. ZT. 20
45° STANDARD DUTY
Hardened gears

No. ZT. 146
360° SWIVEL HEAD
All parts are interchangeable

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90° HEAVY DUTY
Takes 3-jaw chuck

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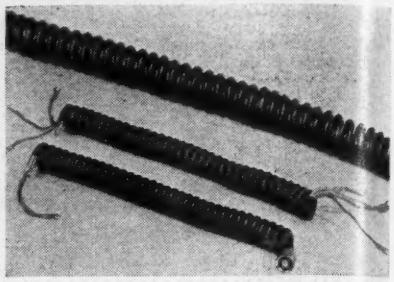
Electrical Cords 77

Developed by the newly formed Cordage, Inc., retractable electric cords, stated to be stretchable to several times original length, are now being distributed through **Kellogg Switchboard & Sup. Co.**, Chicago. Stretch effect is secured



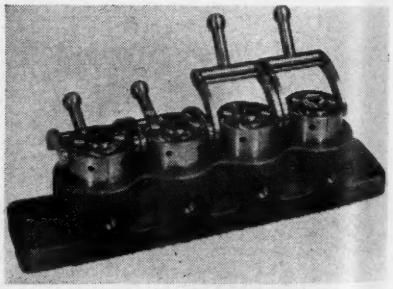
through special spiral-molding of rubber jacket. Cords are made in various lengths and for various current capacities. Aviation industry uses are seen.—**AVIATION, May, '44.**

Prop Governor Test Stand 78

Designed to produce flight-condition vibration on unit being checked, stand developed by **Airplane Mfg. & Sup. Corp.**, North Hollywood, Calif., is for testing, calibrating, and adjusting Curtiss propeller governors. Features: Automatic control to allow governor to control speed of driving unit; a selector switch providing choice of automatic or manual operation; two lamps to indicate closing of the inc. and dec. rpm. governor contacts; and a lamp to indicate any grounded circuit. Driving power is provided by 3 hp. variable-speed unit with 900-3,600 rpm. range (standard, 220-v. a. c., 60-cyc., 3-phase motors; other voltage on request). Chronotachometer unit consists of electric clock, revolution counter, and tachometer. Power is supplied from outside source, and control of stand and motor is through push-buttons.—**AVIATION, May, '44.**

Multiple Collet Holder 79

Aimed to speed up production on milling machines and make possible numerous set-ups to boost output, pictured unit consists of four collet holding fixtures. Offered in either 1 in. or 2 in. size fixtures, may be mounted parallel with, or at right angles to, the spindle. Maker, **Zagar Tool**, Cleveland, says 2, 3, or 4 collets,



or multiples thereof, may be used, length of table being only limiting factor. Where miller is equipped for climb-cutting, two fixtures can be mounted on each side, making a total of 16 collets on one set-up. Center to center of collets is 3½ in. on the 1-in fixtures and 5½ in. on 2-in. fixtures.—**AVIATION, May, '44.**

Tube Cutter 80

Designed to make clean right-angle cuts in processing AN-type flares, tube cutter, made by **Imperial Brass Co.**, Chicago, cuts aluminum, aluminum alloy, copper, brass, or steel tubing in sizes from ⅛ in. to 1⅛ in. o. d. Reported features: Handles great range of sizes; tubing rests against two rollers, to prevent galling or rubbing; special flare cut-off groove is provided in rollers to enable operator to remove a damaged flare with minimum of waste. A reamer for removing burrs is part of tool.—**AVIATION, May, '44.**

Helping the warbirds take a big bite—

Born of combat experience, the Navy's new Curtiss *Helldiver* is heir to all the improvements developed from battle crowded skies since Pearl Harbor. And one of the things that makes it a plane to write home about is its variable pitch propeller.

The intricate gear mechanism for these 3-bladed, full-feathering props is being built by the Detroit Gear Plant of Borg-Warner's Norge Division.

These propellers adjust to every change in altitude, wind resistance, engine speed.

The skillful engineering needed to produce gear mechanisms of such delicate sensitivity is another result of Borg-Warner's long-time principle: "design it better—make it better." More than 100 war items are today benefiting by it.

With the end of the war, this Borg-Warner principle will again be applied to the task of working with you in the automotive industry toward a better living for all America.

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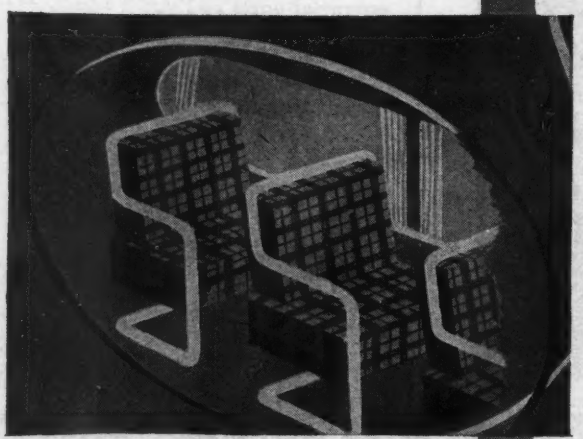
INTERIOR OF VELON!



Imagine an upholstery material *practical* for airline use in any color — from darkest to lightest and brightest! An endless variety of patterns and weaves. A material that keeps *all* its freshness and color-brilliancy — yet tough enough to outlast any plane!

Imagine a material light in weight, stainless, non-inflammable, with moisture absorption virtually zero. Can be wiped dry and spotlessly clean in a minute. *And never shows a sign of wear!*

A material that's both a decorator's and a maintenance man's ideal — for colorful, smart, yet eminently practical plane interiors.

That's not a dream. That's **Velon!* — already tried and tested in actual use.

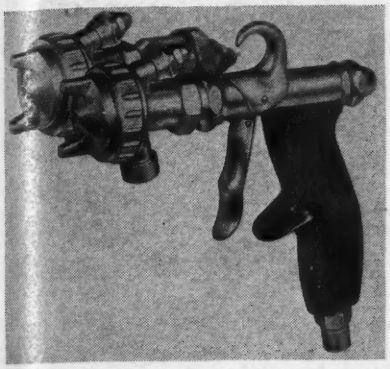
All our production, of course, is now for the government. But remember the name *Velon* — one of tomorrow's vitally important words to every airline, every plane manufacturer.

ANOTHER CONTRIBUTION TO A BETTER WAY OF LIFE *by* **Firestone**

*Trade mark • *pronounced* VEL-LÓN

Multi-Fluid Airbrush 81

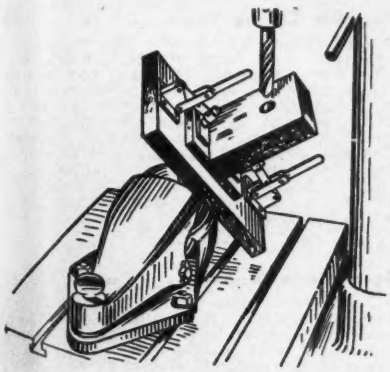
This product of **Paasche Airbrush Co.**, Chicago, is made to mix two or more materials in air as they are applied. A prime use is for spraying Latex and



acetic acid. Further, two or more colors may be applied together to produce unusual blended effects, or materials may be sprayed separately to produce two-tone effects when different colors are employed.—**AVIATION, May, '44.**

Work Holder 82

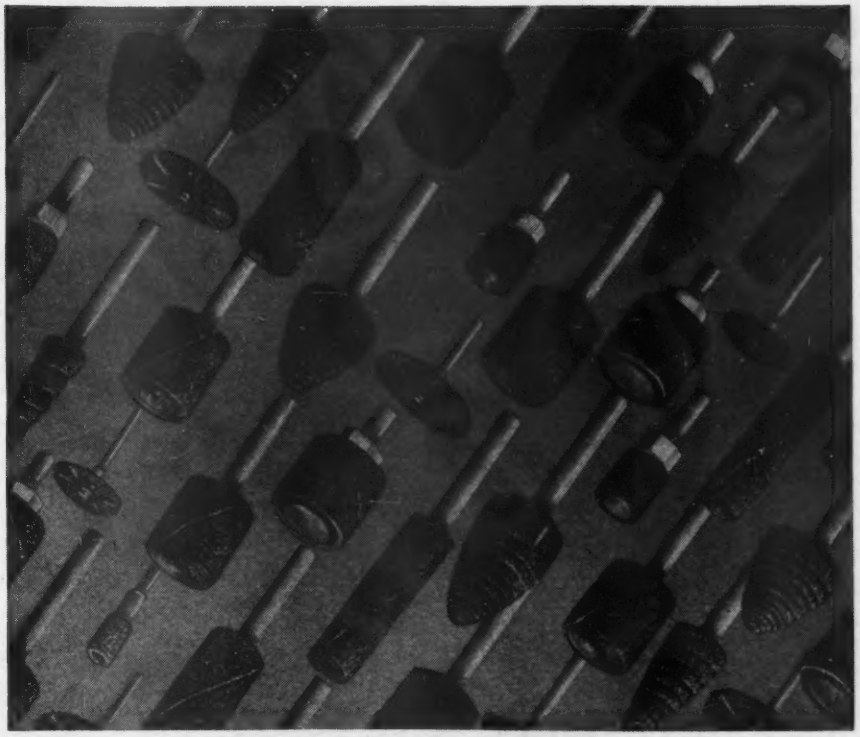
For mounting work rigidly at any angle, Metro Positioner, made by **Metro-Vise Co.**, Detroit, has ball and socket joint and tilts at any compound angle. Devised to be handy for mounting vise or fixture for



checking, milling, drilling (illustrated here), shaping, grinding, welding, pattern making, etc., it is operated by one thumb screw. There are three table sizes: 8 in. x 11 in.; 4 in. x 6 in.; 2¼ in. x 2¼ in.— **AVIATION, May, '44.**

New Sparkplugs 83

For Army aircraft, new sparkplugs offered by **Electric Auto-Lite Co.**, Toledo, feature insulators made from ceramic. Maker states that long life, high mechanical strength and hardness, and high resistance to thermal shock are features of plugs. Left to right in photo: Long reach shielded plug for high-power planes, short reach for lower powered craft, and unshielded for trainers. — **AVIATION, May, '44.**



PICTURE THESE AT 20,000 r.p.m.

You can easily sense what these ready-to-use METALITE Cloth Gadgets will do on the business end of your high speed tools compared to a strip around a workman's finger or held loosely in his hand.

At speeds up to 20,000 r. p. m., isn't it obvious that they will do in seconds what now takes minutes by old-fashioned methods?

For burring, putting on radii, getting into all sorts of odd shaped "difficult-to-get-at" places and for many other bothersome, time-consuming operations, METALITE GADGETS will save time and money and contribute greatly to smoother, better production.

But, from the hundreds of sizes, shapes and grits, don't try to pick the one you think will do the job. We'll do better than that for you. A Field Engineer will tell you the best one for each specific operation and demonstrate on the toughest jobs you dig up for him. Simply call our nearest branch.

Boston, Buffalo, Chicago, Cincinnati, Cleveland, Detroit, Grand Rapids, High Point, Indianapolis, Los Angeles, New York, Philadelphia, St. Louis, San Francisco, Tacoma.

BEHR-MANNING · TROY, N.Y.
(DIVISION OF NORTON COMPANY)
RELIABLE COATED ABRASIVES SINCE 1872

Pressure Relief Valve 84

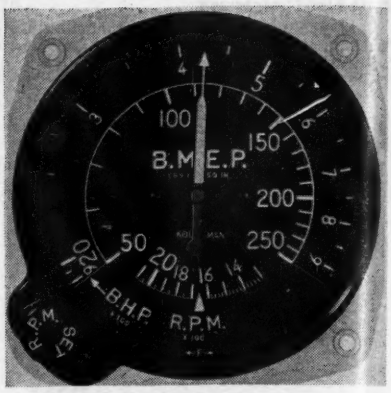
Adjustable, this valve is described as particularly adapted for high pressure systems in aircraft hydraulics. Body is aluminum forging with inner casing of stainless steel. Dashpot is designed to insure smooth operation. Valves are available in three sizes from **American Screw Products,** Los Angeles.—**AVIATION, May, '44.**

Fuel-Line Valve.....85

New "Arrowmatix" valve is for use in conjunction with highly volatile liquids. Danger of cracking valve body during assembly has been eliminated, states maker, **Davidson Mfg. Co.,** Los Angeles, by making AN thread integral with body (no fittings) and weight is reported reduced without loss of strength. Interior of valve has no projections, in order to reduce vapor formations. Valve is for operation in temperatures from —65 deg. F. to above fuel boiling points. Maximum initial breakout torque ranges between 12 and 18 in./lb., but it is stated only 6 in./lb. torque is required to move valve to open or closed position. Operates on a 90-deg. turn to "on" or "off", with spring detent at both positions. There are three types.—**AVIATION, May, '44.**

Horsepower Indicator.....86

New aircraft instrument is designed to eliminate numerous calculations of flight engineer through permitting direct reading of both net horsepower and bmep. from same dial, thus giving direct result of adjustments to controls in their effect on output of engine. This horsepower indicator operates from hydraulic-type torque-balance units functioning from planetary propeller reduction gear, giving indication of net shaft horsepower,



also of motor trouble, such as a fouled spark plug. Maker is Kollsman Inst. Div., **Square D Co.,** Elmhurst, N. Y.—**AVIATION, May, '44.**

Plastic Grommets, Eyelets.....87

Spun acetate grommets and eyelets have been developed by **Precision Paper Tube Co.,** Chicago, for a wide range of uses, many applicable in the aircraft industry. Maker points to factors of insulation, toughness, and resistance of these plastic items. They are made to specification in all wall lengths and diameters and suitable wall thicknesses. —**AVIATION, May, '44.**

Portable Lifting Table 88

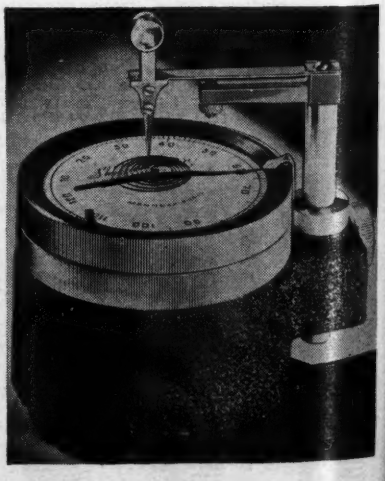
Unit designed to handle dies, to support and level long bars, sheets, frames, etc., and for other applications has simple crank-up mechanism and its flat top table is adjustable to heights from 24 in. to 40 in. so that dies may be slid off to shelves or mountings. Maker, **Barrett-Cravens Co.,** Chicago, offers two sizes, one with table 28 in. x 40 in. with capacity of 3,000 lb. and other with table 24 in. x 32 in., capacity 2,000 lb.—**AVIATION, May, '44.**

Snap Gage Stand 89

New stand is designed to support roll thread snap gage in secure easy-working position, so that inspector may use both hands on work to be checked. Unit is made in two types. Maker is **Vard, Inc.,** Pasadena, Calif.—**AVIATION, May, '44.**

Spiral Spring Tester 90

Sheffield Corp., Dayton, Ohio, has developed torsiometer, comparator to provide means of measuring torsion of small spiral springs. Direct reading can be made in millimeter grams on graduated Manross scale. Instrument accommo-



dates springs up to 2⅞-in. dia. with maximum torsion measurement of 49.5 millimeter grams.—**AVIATION, May, '44.**

Emergency

on ACW alloys?

call Ryerson

● Aircraft quality 8630—X4130—4140 alloy steel bars—hot rolled, cold finished and heat treated—in a wide range of sizes—are carried in stock for immediate shipment from Ryerson plants at Chicago, St. Louis, Cincinnati and Jersey City. These steels conform to specifications: AN-S-14a, AN-QQ-S-684a and AN-QQ-S-752a respectively and are readily available to aircraft manufacturers and their subcontractors under the ACW program. A special booklet of stocks on hand, "Aircraft Alloy Steels," including condensed specifications for AMS and AN-S steels, will be sent to you on request.

Other steels at eleven Ryerson plants comprise over 10,000 different kinds, shapes and sizes—everything in steel. Call your nearby Ryerson plant first—for quick action on steel. Joseph T. Ryerson & Son, Inc., Steel-Service Plants at: Chicago, Milwaukee, St. Louis, Detroit, Cleveland, Cincinnati, Buffalo, Boston, Pittsburgh, Philadelphia, Jersey City.

RYERSON STEEL-SERVICE

The Answer···CURTISS HELLDIVERS
The ANSWER to the Navy's urgent need for deadlier, higher performance dive bombers . . . and to their call for continuous high production of them!
Today, according to the nations press, Curtiss Helldivers, carrying heavier bomb loads further, faster, are delivering their knock-out punches to the Axis. Designed to wreak destruction—mass produced to hasten Peace—powerful opponents to out-perform the enemy's best—here is Curtiss' resounding ANSWER!
Another Contribution of
Curtiss-Wright Corporation
AIRPLANE DIVISION
Toward Winning This War
BUFFALO - COLUMBUS - ST. LOUIS - LOUISVILLE

ADD ANOTHER CHAPTER TO THE HISTORY OF AMERICAN AVIATION

Jet Propulsion —

Think you're seeing Buck Rogers' plane? You're not. You are looking at the performance of America's newest fighter—the first jet propelled airplane to be accepted by the United States Army Air Forces.

And with the official announcement of this propellerless plane, a new chapter begins in the history of world aviation.

Now we'll take you behind the scenes and tell you the story of how these planes came into being.

In England there was designed a revolutionary new type of engine which could propel an airplane through the sky by spewing out a terrific blast of air.

The General Electric Company here in America further developed and built engines utilizing this principle.

By choice of both G. E. and the Army Air Forces officials, Bell Aircraft was selected to design and construct planes incorporating this Jet Propulsion engine.

Within two weeks after being notified of this project on September 8, 1941, Bell Aircraft engineers submitted a general arrangement for a new plane housing two Jet Propulsion engines. These designs were immediately accepted by the Army Air Forces.

One year and three weeks later, on October 1, 1942, this revolutionary type of aircraft, exactly on schedule, rose from the flying field at a secret base, climbed into the rarefied atmosphere where a conventional plane loses its efficiency and traveled at high speed.

Now that the story of this new jet propelled plane can be told, Bell Aircraft wishes publicly to express its appreciation to the officers of the Army Air Forces who have contributed so much to this project. We have learned many things which will aid us to pioneer in building safer, better and lower-priced aircraft when peace returns. © Bell Aircraft Corporation.

MEMBER AIRCRAFT WAR PRODUCTION COUNCIL—EAST COAST, INC.

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Ordnance Division, Burlington, Vt.
Georgia Division, Marietta, Ga.

PACEMAKER OF AVIATION PROGRESS

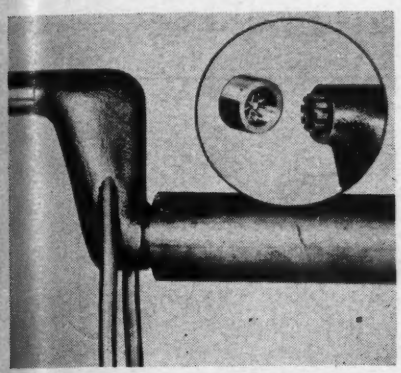
BUY WAR BONDS AND SPEED VICTORY

Lighting System Component.....91

Unit for aircraft lighting systems made by **New York Transformer Co.**, N. Y. C., is stated to weigh only 8 oz. It is designed for very low temperature rise of 30 deg. C. to permit operation over all ambient from –65 deg. C. to 70 deg. C. and at altitudes to 50,000 ft.—**AVIATION, May, '44.**

Offset Tip-Cooled Electrode.....92

Offset spot welding electrode made to be cooled at its tip is announced by **Frostrode Products,** Detroit. Feature is strengthening of structure through having "solid" cross section at point of greatest stress, with cooling liquid entering offset electrode below knee and thence flowing through coolant guide into finned, replaceable "Frostcap" which forms electrode's tip. Function of coolant guide is to concentrate cooling action at vary tip of electrode. Electrode, adaptable to



any standard holder, is available with ⅝ in., ¾ in., or ⅞ in. o.d. Frostcap of hard drawn copper or Mallory 3 metal.—**AVIATION, May, '44.**

Russia's Air Power

(*Continued from page* 123)

The use of wooden construction apparently involves some, but not excessive increases in structural weight. Its resistance to explosive projectiles is poorer, although the damage done by solid projectiles is comparable with that done to duraluminum structures. The extensive use of wood for smaller types of airplanes is apparently dictated by shortages of duraluminum, machinery, and skilled labor.

In early September, our group was flown to a large fighter base on the central front, from which Bell *Airacobras,* Douglas A-20's, and a variety of Russian fighters were being operated. There we were given opportunities to discuss the *Airacobra* with pilots and technicians.

We were introduced to the pilots and technicians of the P-39 squadron at the base. The pilots were apparently about the same age as those performing similar duties in our own AAF, although some of the technicians appeared to be younger and the latter group included several girls. The writer was impressed by the difficulties of performing maintenance operations under combat conditions, with little shelter available in which to work. Since most combat operations take place during the day, it is common to service the airplanes at night.

In discussions which took place with pilots and technicians, we were made acquainted with the good and bad points of the *Airacobra* as operated at that base. Certain difficulties were noted to be peculiar to operating conditions in Russia. Necessity for the use of very high octane fuels was particularly objectionable, since such fuel is not required for Russian-built airplanes and thus presents a special transportation difficulty.

To an American, the entire transportation problem in Russia seems staggering, since few good roads exist between populated places. This puts a very heavy load on the railroads and results in extensive use of transport airplanes to move personnel and light types of equipment. There can be no doubt that the large Lease-Lend exports of all-wheel drive American Army type trucks is of great importance in the success of the recent Russian drives because these vehicles are capable of operation on very poor roads.

It seems probable that in postwar development of the Soviet Union, the transport airplane will play a very important part, inasmuch as the present railroad system is likely to be expanded only where the tonnage to be transported precludes the use of airplanes and highway transportation.

Shortly after returning to Moscow we began another trip, being transported in

PRECISION
HYDRAULIC TESTING MACHINE
with Pendulum Load Indication
MORE ACCURATE, MORE DEPENDABLE
FOR PRODUCTION TESTING because:
Pendulum load indicator operates on the natural laws of gravitation.
...This principle of operation is not affected by temperature changes
or subject to metal fatigue....Write for descriptive literature and quotations.
RIEHLE
TESTING MACHINES
Division of
AMERICAN MACHINE AND METALS, INC.
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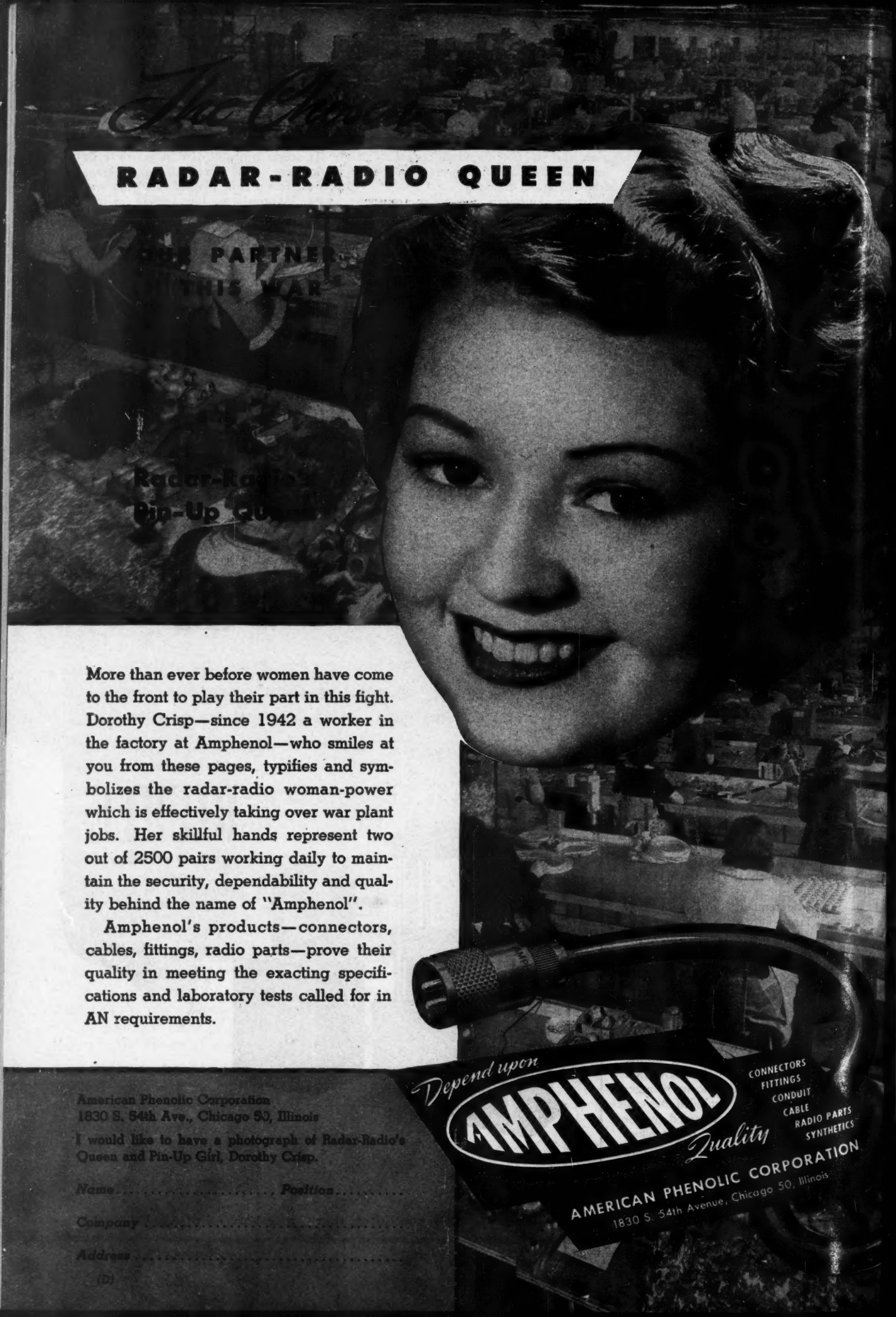
ARMY
NAVY
Other Products: IMPACT TESTERS • VICKERS HARDNESS MACHINES • BRINELL HARDNESS TESTERS • MEASURING INSTRUMENTS


RADAR-RADIO QUEEN
More than ever before women have come to the front to play their part in this fight. Dorothy Crisp—since 1942 a worker in the factory at Amphenol—who smiles at you from these pages, typifies and symbolizes the radar-radio woman-power which is effectively taking over war plant jobs. Her skillful hands represent two out of 2500 pairs working daily to maintain the security, dependability and quality behind the name of "Amphenol".
Amphenol's products—connectors, cables, fittings, radio parts—prove their quality in meeting the exacting specifications and laboratory tests called for in AN requirements.
American Phenolic Corporation
1830 S. 54th Ave., Chicago 50, Illinois
I would like to have a photograph of Radar-Radio's Queen and Pin-Up Girl, Dorothy Crisp.
Name ..... Position .....
Company .....
Address .....
(D)
Depend upon
AMPHENOL
Quality
CONNECTORS
FITTINGS
CONDUIT
CABLE
RADIO PARTS
SYNTHETICS
AMERICAN PHENOLIC CORPORATION
1830 S. 54th Avenue, Chicago 50, Illinois

Send for a Photo of Dorothy—Radar-Radio Queen

All You Need Send is Your Name and Address—Use the Coupon

Pictured here is Dorothy Crisp—a typical wholesome American girl—busy every day on Amphenol's production line. She was chosen first by Amphenol's twenty-five hundred employees as their representative. Then she was picked as Radar-Radio Queen of Chicago's fifty-two radar and radio plants.

Dorothy's smile is offered here, as an encouragement to the army of workers who are using Amphenol products in building the electrical and communications war equipment . . . and to the men in the Armed Forces who are so effectively using that equipment in the field.

a Russian-built Douglas to a training center about 180 mi. away. Here we were acquainted with the best and worst points of the P-39 from the standpoint of the instructor-pilots and local maintenance men. We were able to exchange service information and describe changes that had been made, in order to overcome the maintenance difficulties which the Russians were then experiencing, on airplanes then on the production line. Here again the general impression was gained that the P-39 was performing well.

As has been obvious in our experiences with airplanes that are operated by our AAF, training and combat service often result in differing types of service troubles; for instance, training units have more difficulty with brakes and landing gear. It was noted that Russian technicians, even at advanced bases, usually must make repairs with fewer powered tools than would normally be available to our own technicians.

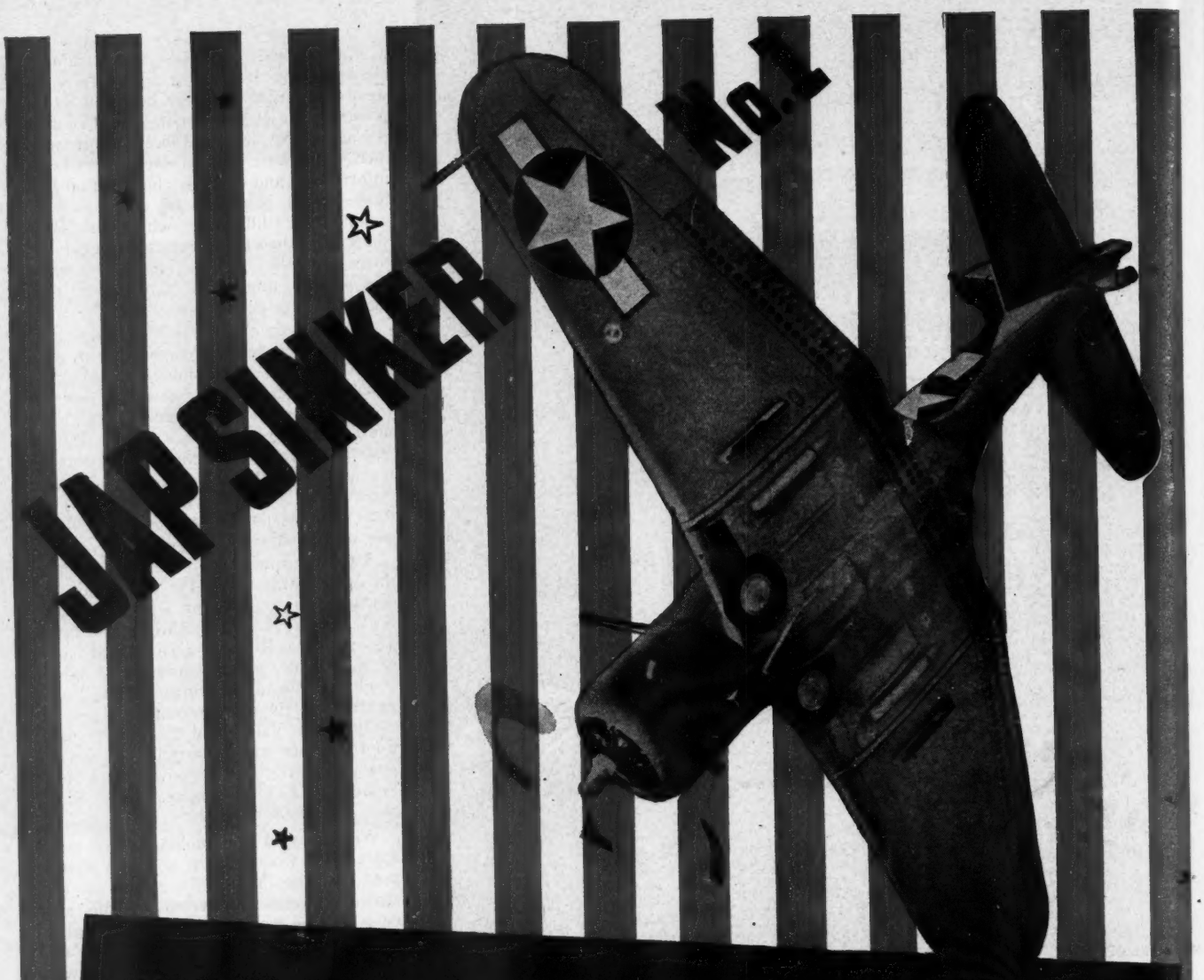
After returning from the training base, the writer was given the opportunity to discuss design problems with Alexander S. Yakovlev and Prof. Shiskin, the latter a prominent Russian aeronautical engineer, and the former a designer of fighter airplanes who is best known for the Yak-1 fighter and its more recent versions, including the Yak-7 and the Yak-9 mentioned earlier in this article. These are single-engine fighters powered with a liquid-cooled V-12 engine. The Yak-1 was first used in 1941.

We discussed the combination of metal spars with wooden skin and ribs that is used on the Yak-9, in which a thin strip of wood is riveted to the spar caps and the wood covering is then glued to the strip. I was told that the Yak-1 originally had an all-aluminum-alloy wing of conventional construction, but that material shortages had forced a re-design in wood. The present type of construction was adopted after running careful vibration tests of sample parts, and in actual service very little trouble has been experienced.

It was mentioned that flutter speeds were likely to be low for wooden wings. Prof. Shiskin agreed and said that they made an extensive flutter analysis of each new design.

It was indicated that the flight load factors for fighter aircraft that are used by Russian designers are slightly higher than are used for U. S. Army fighter types and that the height of drop for the landing gear is greater. However, no landing load factor is specified but depends upon the shock-strut characteristics.

It is quite likely that we can learn much about front line air warfare from the Soviet Air Forces, which have made very successful use of certain specialized types of airplanes. The most outstanding of these is the *Stormovik*, or Il-2, a very heavily armed and armored single-engine attack airplane. Escorted by fighters, it operates at low levels and deals very effectively with artillery positions, machine gun nests, and tanks. Although relatively slow and not highly maneuverable, its ability to resist the effects of small caliber fire permits it to operate at heights of about 80 ft. from the ground,



YOU should know this plane—credited with sinking "more enemy combatant tonnage than all other *arms* of the services"! It's "Old Faithful," the *Douglas Dauntless* — veteran of Midway, Guadalcanal, the Gilbert and Marshall Islands. In the Solomons, the Dauntless was used to bomb out Jap pill-boxes within a few yards of our own forces — that's *precision bombing* with a vengeance!

Jack of all jobs, the master of most, the Dauntless has paid handsome premiums on the sound design and precision workmanship that kept her fighting when contemporary planes had become obsolete . . . We at Kenyon, with a tradition of precision workmanship, feel privileged to supply tab control units for the hard-hitting Dauntless — one of the many American fighting and cargo planes which have employed Kenyon precision work, from wind-tunnel models to finished parts or instruments. We look forward to performing similar service for the manufacturers of future planes, as well.

War or peace—when you need precision parts or instruments, you can rely on Kenyon to supply them, in quantity and on time — even if they have never been made before!

For Precision Parts . . . Call on Kenyon

KENYON
INSTRUMENT CO., INC.

HUNTINGTON, L. I. *If it's Kenyon made* NEW YORK *It's precision-built*

DO MORE FOR THE WAR IN '44 — BUY MORE WAR BONDS!

where it is fairly safe from large caliber anti-aircraft installations. Its heavy armor plating forms the forward fuselage structure, and it is equipped with bombs in wing bomb bays, cannon of from 20 mm. to 37 mm., machine guns, and rocket guns.

During the present war, there has been considerable interest among American engineers in Russian aeronautical developments, and several articles have been published dealing with Russian airplanes, though they unfortunately often have contained inaccurate or obsolete information, partly because of language difficulties and the fact that the information was gathered by writers having insufficient technical training.

In postwar years, it is to be hoped that such difficulties can be overcome to the extent that more accurate articles are published dealing with Russian airplanes and with Russian technical progress.

"Packaged" Airports

(*Continued from page* 118)

The largest, or Type D, buildings are developed from Type C structures by addition of a control tower and a wing having space for customs and immigration services, medical examination, and other services in connection with international traffic. This wing can be entirely isolated from the rest of the building so that international passengers can be segregated pending completion of arrival or departure clearances. Type D buildings are developed to handle an uninterrupted flow of traffic in centers up to 100,000 population, for small international airlines, large market centers, feeder and trunk line connecting points, large military bases, or other similar uses.

In a book on packaged airport equipment now being prepared by Westinghouse, four different typical airports are described. The almost-infinite number of combinations available through varied selections of the assemblies make it possible to set up practically any type of landing and service facilities desired in small and medium size airports of current design.

Within the bounds of cautious prediction, we feel nevertheless that the four basic plans have taken future airline development into careful consideration and that they will reflect modern practice in equipment design for some years to come. Due thought has been given to the ever-changing aspects of air transportation and the plans are felt to be flexible enough to permit future expansion or alteration without incurring any very appreciable loss.

Essentials—No Frills

In every case, the airports contain the elements of equipment considered essential to regular and successful operation, but for economy no useless "frills" have been included. In each case, to make sure of completeness, it has been assumed that electric power is not available at the location, that night flying will be done, that full facilities will be needed for radio beacon, ground-to-plane, and airport-to-

How much PUNISHMENT can they take?

ALLEN KNOWS!

IT'S AN unknown quantity in men

fighting against odds. In the crucial moments, we only know it takes all they've got to come through. *How much* they've got is the measure of their endurance and heroism. . . But in hollow screws, the measure of endurance is taken scientifically in the Allen laboratory.

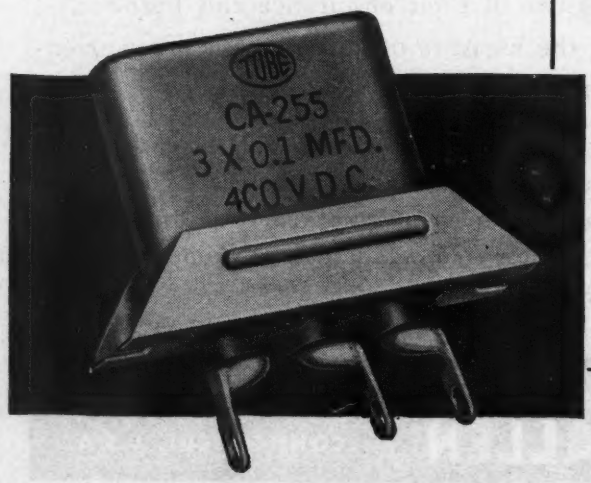
Here, Allen screws must prove *exactly* how much punishment they can take. It's registered on the dials of testing machines, — testing for tensile strength, for yield point, elongation, reduction of area, Izod impact and Rockwell hardness. Your Industrial Distributor sells the screws that *come through!*

THE ALLEN MANUFACTURING COMPANY
HARTFORD, ★ ALLEN ★ CONNECTICUT, U.S.A.

OLD FAITHFUL GEYSER, Yellowstone National Park. Geologists believe it began erupting before the last glaciation, about a million years ago. Within record, Old Faithful has erupted continuously at about 65-minute intervals, spouting a column of water 95—130 feet high for 4½ minutes.

STILL GOING STRONG

LONG, UNINTERRUPTED service under all operating conditions is the characteristic you want most in a capacitor. Tobe Capacitors serve so well and so long because every step in their manufacture is checked and cross-checked by rigid inspections. Constant improvement through constant research is the promise performed by Tobe engineers. An example is the Tobe CA-255 Capacitor, shown below, now available in a new drawn container of improved construction. Why not call on Tobe for prompt, specialized help on your capacitor problems?



SPECIFICATIONS—CA-255

Mineral Oil Impregnated and Filled. Aluminum Foil. Highest Grade Kraft Tissue.

CAPACITY RATING..... 3 x .1 mfd.
VOLTAGE (working).....400 V. D. C.

DIMENSIONS: 1 11/16" wide: 9/16" deep: 2 7/16" long, including channel mounting bracket. Mounting centers 2⅛". Three terminals ½" on centers. Height of terminal ¾". Diameter of mounting holes, .144.

FEATURES: Rugged Channel Mounting Bracket securely soldered to container . . . Increased terminal insulation . . . Rigid terminal lugs afford ample space to handle No. 14 stranded wire . . . Improved streamlined drawn container instead of fabricated can . . . Type, capacity and voltage die-stamped on container. Meets U. S. Army Signal Corps Specifications 71-516-E.

Other values and voltages may be obtained in above mentioned container construction. Send for details of our "OM" and "OD" Capacitors.

TOBE DEUTSCHMANN CORP. TOBE CANTON · MASSACHUSETTS

A small part in Victory today...

A BIG PART IN INDUSTRY TOMORROW!

airport communication, and that meteorological data are not otherwise available at the site.

As developed by Westinghouse there are seven distinct advantages to the packaged airport. First, speed is obtained by eliminating tedious engineering for setting up drawings and bills of materials, purchasing, negotiations, routine follow-ups, and other detailed work. Second, our engineers have developed new packaged assemblies for many materials used in airports, and they have built new units that will result in great simplification. Third, we recognize the changing nature of the whole air transport picture with consequent need for flexibility, so that all materials included in the packaged assemblies may be enlarged, modified, or shifted from airport to airport without grave loss.

Fourth, purchase and shipments are consolidated. Westinghouse gathers at consolidation warehouses all materials into their proper assemblies for unit shipment, thus the purchaser deals with but a single supply source and has no awkward waits for missing installation parts. Fifth, shipments are facilitated. The packaged material has been studied carefully to make shipping easy; packaged airports can be moved entirely by air if necessary. Sixth, field erection and maintenance are kept as simple as possible. Materials and equipment have been chosen with the thought always in mind that erection and maintenance problems might readily impose serious difficulties. Westinghouse International furnishes instructions covering erection and maintenance of all materials, and it has tried to simplify these tasks to the utmost.

Seventh, but far from least important, is the matter of cost, which packaged airport equipment lowers materially. This is accomplished in part by elimination of a great deal of field work, piecemeal engineering, costly delays due to missing parts, and routine follow-ups. We believe these, coupled with the advantages of mass purchasing, bring the ultimate cost of the installed airport to a level considerably below that possible by other means.

Market Research

(*Continued from page* 124)

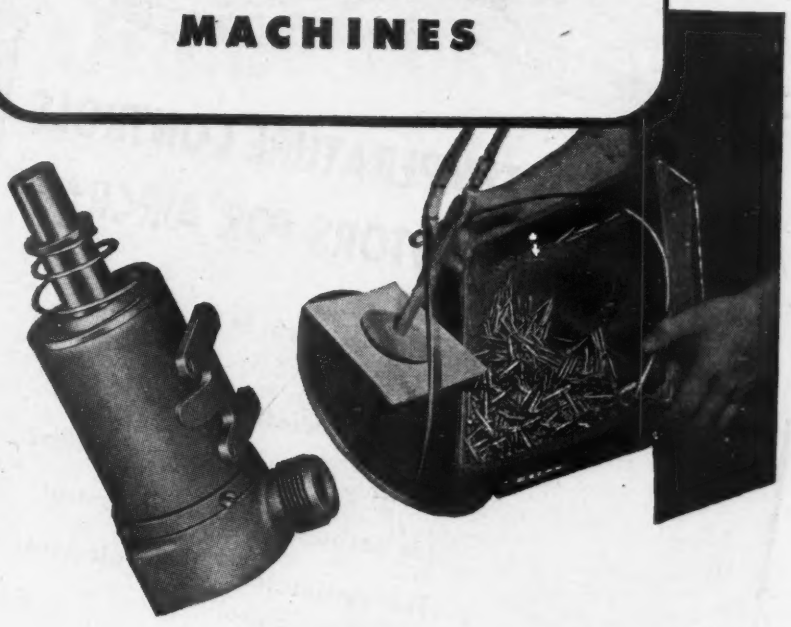
Even though there be a reaction against such spending, it is obvious we will need thousands of planes for self protection, for training new pilots and, just as important, for research. The fallacy of building but a few hundred planes each peacetime year for military purposes has been demonstrated, but the final make-up and size of the standing force must await the peace and the solutions to the factors noted above.

The transport market can more easily be evaluated for contemplated domestic commercial expansion, since it is already in its formulative stage.

Basically the market study procedure calls upon the researcher to—

1. Survey and analyze each domestic airline operating company as to present

SCREENING MEN MATERIALS AND MACHINES



Cannon Quality Control operates to eliminate failure wherever it may be found. It is a continuous "screening" process that grades out materials that do not measure up to critical standards—that scraps malfunctioning tools, jigs, machinery and equipment—that shifts men and women to the jobs they are best suited to handle.

It's relentless in the way it operates but it results in a product that we are glad to trade-mark and on which you can depend. Cannon plugs are good plugs because all the elements that go into them—men, materials and machines—are good.

VISUAL AIDS FOLDER

The many visual training aids offered by Cannon Electric include wall charts, training films and engineering bulletins. These are listed and described in a new four page folder, available on request. Address Dept. A-110, Cannon Electric Development Company, 3209 Humboldt Street, Los Angeles 31, California.

CANNON ELECTRIC

Cannon Electric Development Co.
Los Angeles 31, California

Canadian Factory and Engineering Office:
Cannon Electric Company, Limited, Toronto

Representatives in principal cities—Consult your local telephone book

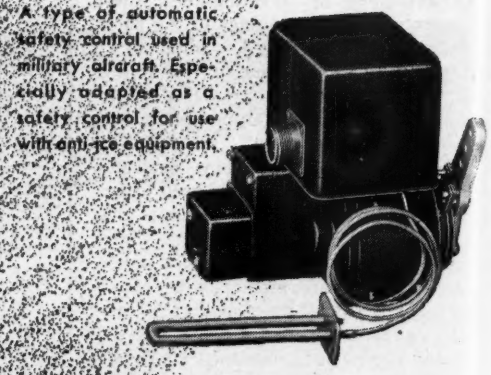
MOTORIZED TEMPERATURE CONTROLS AND SERVO MOTORS FOR AIRCRAFT

Provide remote, automatic control of aircraft flight operations:

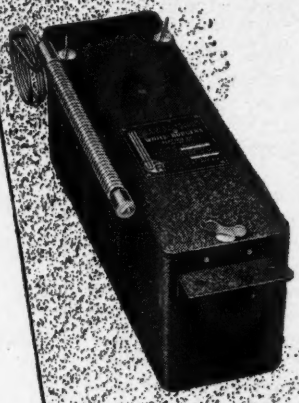
- ...for cabin heating control
- ...for anti-ice temperature control
- ...for carburetor mixture control
- ...for carburetor intake air temperature control
- ...Servo throttle motor
- ...Servo torque motor

Manufacturers' requests for engineering data and application information are invited.

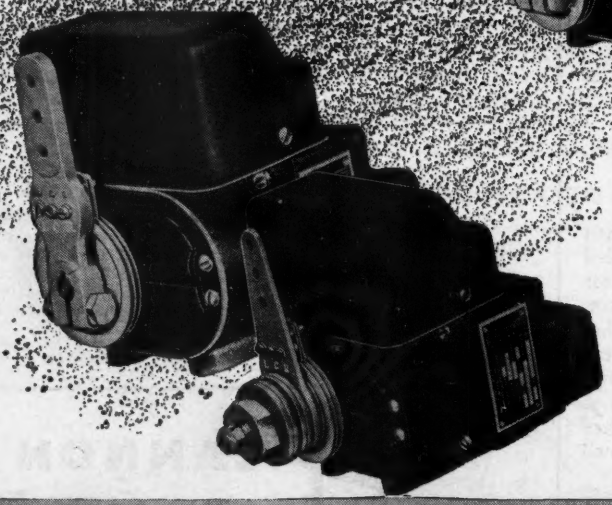
★



A type of automatic safety control used in military aircraft. Especially adapted as a safety control for use with anti-ice equipment.



Motorized temperature modulating control for maintenance of cabin or cockpit temperature. Also carburetor air temperature and similar applications requiring close control.



Typical "muscle motors," these Servo motors are supplied in several types for applications involving additional power requirements. Three types are illustrated; others available to meet your specific requirements.

LET'S GO! U.S.A. ★ KEEP 'EM FLYING! ★

WHITE-RODGERS ELECTRIC CO.

SAINT LOUIS, MO.

equipment and projected expansion plans for equipment for the postwar period.

2. Survey and analyze each American-operated international airline company as to present equipment and projected expansion plans for the postwar period.

3. Survey and analyze fixed base operators as to present equipment and plans for contemplated expansion in the postwar period.

4. Survey and analyze foreign-operated airlines for new equipment and make contact with their representatives in the United States as to plans for new equipment and for resumption and expansion of service in the postwar period.

From this data an area survey of specific territories can be formulated to give a detailed blueprint of the market covering virtually all customers and prospects and classifying them into groups in accordance with their potential value to the manufacturer.

Comparison of this analysis with past company sales clearly indicates where additional business must come from if the company position is to be substantially improved.

An area survey serves as a basis for sales planning and coverage of potential accounts with a full analysis of background and potential as it exists for definite areas.

The personal plane market requires more study and research, as the past market has been exceedingly meager.

Nearly all students of economics, and others who have given considerable thought to postwar marketing, agree that there will be a period of great prosperity immediately following the war. There will be ample purchasing power in the hands of the public—a pent-up demand estimated at $135 billion, with $104 billion expected to be available for immediate spending, plenty of plant capacity to produce planes, and adequately trained labor to use all the productive capacity which will be available. Should the war end in 1945 or 1946, the American public will have the greatest accumulation of unused buying power in its history.

The great expansion in war production has been reflected in an unprecedented rise in national income. Department of Commerce estimates put the 1943 national income at an all-time high of $147 billion— an $89.2 billion increase over 1940 and $97.5 billion over 1934. Although all major types of income have shared in this increase, by far the greatest gain occurred in wage and salary payments, representing 73 percent of the national income.

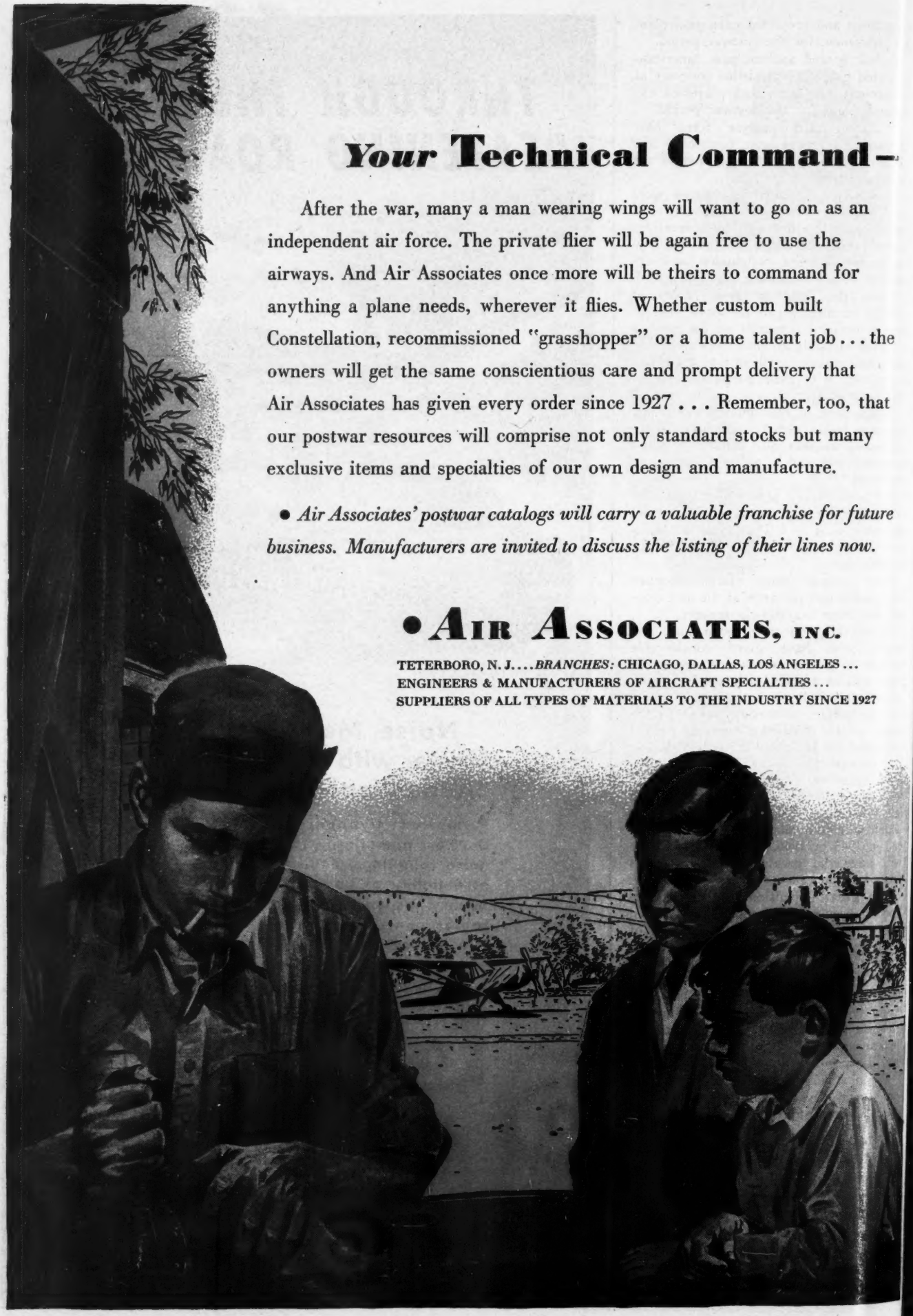
Planning for the personal plane market should begin with the premise that no experience or statistics of the past can serve as a reliable blueprint for the future. Management is then required to take a critical attitude toward its policies, an attitude which involves an unwillingness to assume the validity of past practices or the wisdom of continuing them.

The procedure can then be made simple and practical by—

1. Stripping away generalities which fail to suggest positive action.

2. Reducing to their proper stature of

THROUGH THE DEAFENING ROAR
Noise Meets Its Master with Permoflux Acoustical Devices
Permoflux Dynamic Acoustical Devices, operating under extreme noise conditions, have proved the essentiallity of uniform, wide frequency response. No other single factor contributes more to the intelligible transmission of vital war messages. With the coming of Peace, there will be many Permoflux engineered products to improve the efficiency and operation of speech transmission equipment.
BUY WAR BONDS FOR VICTORY!
TRADE MARK
PERMOFLUX
PERMOFLUX CORPORATION
4916-22 W. Grand Ave., Chicago 39, Ill.



Your Technical Command—

After the war, many a man wearing wings will want to go on as an independent air force. The private flier will be again free to use the airways. And Air Associates once more will be theirs to command for anything a plane needs, wherever it flies. Whether custom built Constellation, recommissioned "grasshopper" or a home talent job . . . the owners will get the same conscientious care and prompt delivery that Air Associates has given every order since 1927 . . . Remember, too, that our postwar resources will comprise not only standard stocks but many exclusive items and specialties of our own design and manufacture.

• *Air Associates' postwar catalogs will carry a valuable franchise for future business. Manufacturers are invited to discuss the listing of their lines now.*

• AIR ASSOCIATES, INC.

TETERBORO, N. J. . . . *BRANCHES:* CHICAGO, DALLAS, LOS ANGELES . . .
ENGINEERS & MANUFACTURERS OF AIRCRAFT SPECIALTIES . . .
SUPPLIERS OF ALL TYPES OF MATERIALS TO THE INDUSTRY SINCE 1927

importance and probability the various alarming aspects of the postwar aviation manufacturing business which are amplified by some interests to make political issues.

3. Collating for examination the specific conditions under which the individual business may expect to operate after the war.

4. Distinguishing circumstances which can be controlled from those not susceptible to control, so that no time or energy are wasted on things that the individual alone cannot correct.

5. Bringing into sharp perspective the conditions which are favorable and should be capitalized on, and those which are detrimental and should be counteracted.

Postwar personal plane market planning must, in addition, be adaptable to change. This flexibility to conform to a new "aviation climate", and willingness to compromise, are fundamental to making plans now for taking advantage of favorable developments.

A few of the general factors which the personal plane manufacturer must consider in postwar planning to assure most efficient conversion to peacetime operations are reflected in the following questions:

1. From what classes of customers does the sales department expect to obtain its postwar orders? How many salesmen will it require, and where should they be stationed?

2. What changes in sales methods should be contemplated, and if so, what plans are being made to put these into effect as soon as possible?

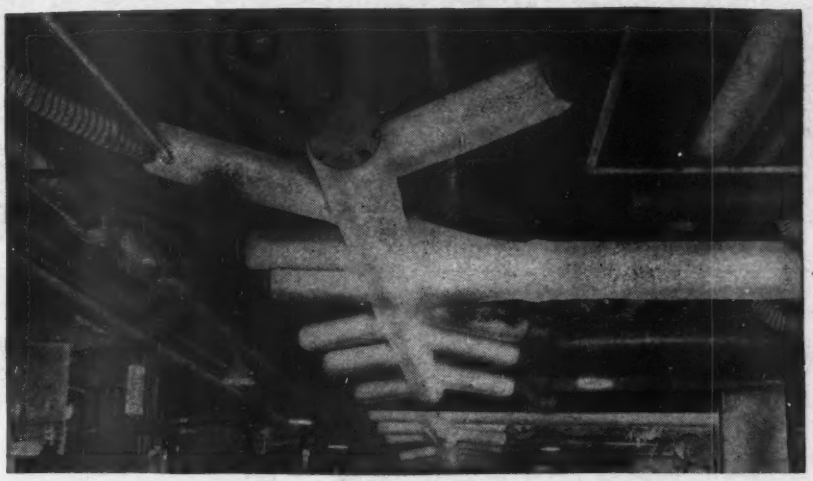
3. What types of planes must be available for sales as soon as possible after the war is over? How soon must engineering or design departments start work on such planes before they can be put into production? What plans are being made to set aside men for development or designing of such planes?

4. What plans are being made to convert plants to peace-time production, and how soon can plans be available so they may be put into execution without delay?

5. What will be the volume of private flying? It is to be noted that determination of those who will be interested in purchasing depends on quantitative analysis for basic production programs. To this end analysis of the following five points should be given careful consideration:

a. Cost, utility, and safety of plane or planes under consideration.
b. Landing facilities in territory where plane is to be used.
c. Attitude of the federal government on regulations which will affect construction and operation of planes and also the individuals who fly them.
d. Approximate number of individuals whose interest has been aroused by direct contact with aviation, either in the aircraft industry or in service.

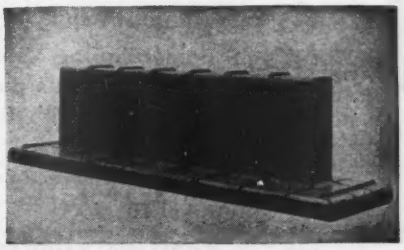
Analysis of the export market will depend to a great extent on what is done with surplus military aircraft. How-



Skill Counts in Making a Product Like This

From coast to coast in the plants of major manufacturers, the plant analysts from Pressed Steel Company are well known and welcome. Above is a photograph of actual installation of an Alloy Exhaust Manifold, made for a noted car manufacturer. This Manifold carries exhaust gasses and fumes from motor testing blocks: another of the highly technical and complicated products we manufacture and of which are are justly proud.

CARBURIZING and ANNEALING EQUIPMENT



We are geared to give you Heat Treating equipment that will reduce manufacturing costs and increase production. We are pioneers in the manufacture and distribution of Lightweight Carburizing and Annealing Equipment — built in all sizes and to any specifications.

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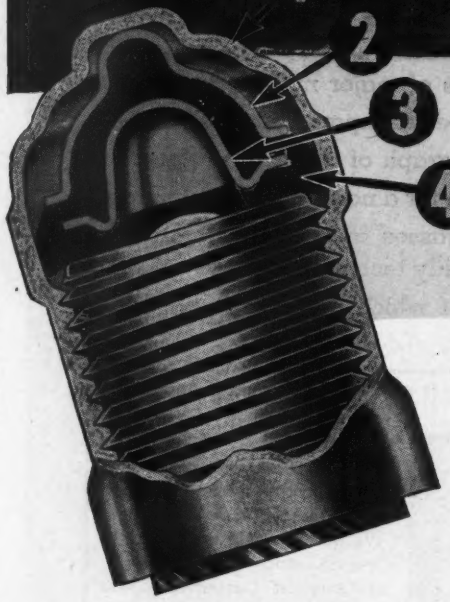
PRESSED STEEL COMPANY PRODUCTS: Carburizing and Annealing Boxes, Thermocouple Protection Tubes, Seamless Steel Cylinder Caps, Seamless Steel Neck Rings, Welded Alloy Tubing for High Temperature and Corrosive Application, Radiant Tubes, Inner Covers and Base Sheathes for Steel Mills



A TWIST OF YOUR FINGERS— MAKES A TON-TIGHT* SEAL

SCHRADER FEATURES

1. Valve Cap body or shell.
2. Brass Swivel Plate allows Cap Shell to turn independently of rubber washer as Cap is applied. This assures proper seating of washer and prevents distortion.
3. Brass Dome-Shaped Plate provides an indestructible chamber for safe clearance of valve core pin.
4. Molded Rubber Washer seals valve mouth when Cap is screwed on firmly by hand; while rubber between brass plates 2 and 3 provides spring action to maintain positive seal.

LOSS of tire air pressure, means extra tire wear, and added cost to your customers. But you can help cut this loss, and keep their cars rolling, by applying a Sealing Valve Cap to every tire serviced.

Schrader Sealing Valve Caps screwed down finger-tight, are designed to maintain a positive seal. This seal keeps air pressure in and keeps dirt out. Vibration will not loosen the cap. It will not work off.

To help conserve your customers' valuable rubber do these three things:

First: Make sure every tire you service is equipped with a Schrader Sealing Valve Cap.

Second: Whenever you check tire pressures, *replace* the Valve Caps.

Third: Tell your customers why you are applying Schrader Valve Caps. It means dollars saved in additional tire mileage and prevents hours of roadside delay.

*When a Schrader Sealing Valve Cap is tightened with full finger strength, a downward force of about 50 pounds is exerted against the top of the valve mouth. The actual effective contact surface between cap washer and valve mouth is about 1/40 of a square inch. Multiplying 50 pounds by 40 gives the equivalent per-square-inch pressure—2,000 pounds.

Schrader
CONTROLS THE AIR
REG. U.S. PAT. OFF.

ARMY E NAVY

SCHRADER TIRE VALVE CAPS

Guaranteed Air-Tight Up to 250 Pounds Pressure

A. SCHRADER'S SON, ***Division of Scovill Manufacturing Company, Incorporated,*** **BROOKLYN, NEW YORK**

ever, consideration should be given to the whole broad question of postwar export markets. American planes will be in great demand all over the world until foreign competition again has plant facilities. For a short time—possibly three to five years—we will be able to go anywhere and sell on favorable terms within whatever framework of export financing may then be available, if surplus is properly disposed of. What the U. S. does and how it handles itself in this time will mean a great deal later. We can cultivate friends by fair dealing or we can alienate customers by sharp practices. If we really want to hold export markets we must cultivate them just as assiduously as we cultivate domestic markets. We must study them and learn how to do business in them as Europe has done. Again this is a job for market research, for if the effort at cultivation is to be on a long-time profit basis, it cannot be hit or miss.

Obsolescence will become an increasing factor in determining the total volume of export production impelled by the foreign desire for improved models. A corollary result will be greater emphasis on the ways and means of disposing of used surplus military aircraft.

What should be some of the broad objectives of postwar aviation for all business concerns?

Few sound business decisions of real importance can be made until responsible executives have before them the best possible figures on such elements as:

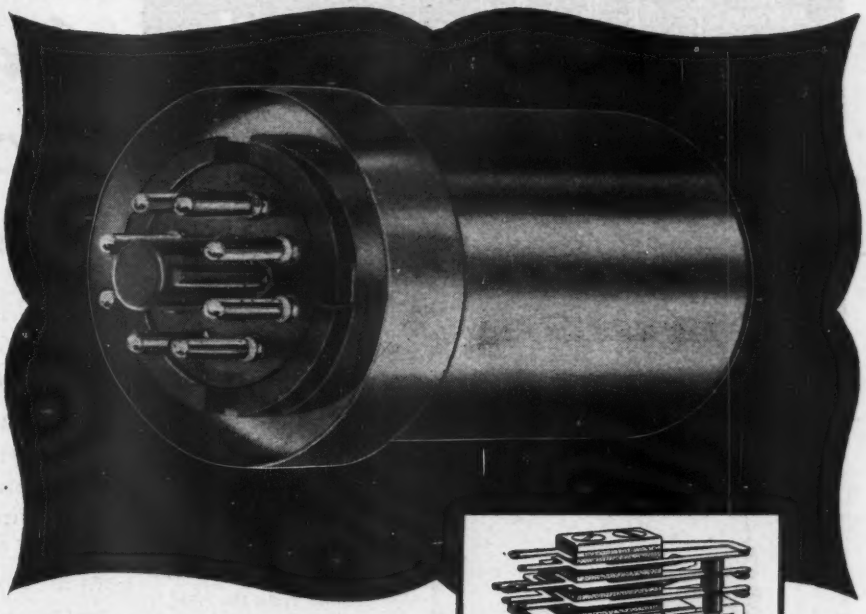
1. Potential sales or gross returns from the project.
2. Appraisal of the domestic and export aviation market to be entered—its size and possibilities for expansion.
3. A schedule of the preparatory work to be done—by whom and at what expense.
4. Total investment required—when and for what.
5. Production or operating costs.
6. Marketing methods and costs.
7. Administrative time and costs.
8. A timetable and budget of outlays in comparison with revenue.
9. Projected profits at various levels and under various conditions.

How to make long range plans definite, in spite of all the uncertainties as to what the postwar world will be like, is one of the baffling problems of many companies. The only practical line of attack, to the best of our knowledge, is to apply the principle called "concentric planning." This involves careful estimating for each or several hypothetical situations and perhaps for a variety of conditions directly affecting the project, but the end result will be definite figures on which to make plans. This calls for more than annual, or short form figures, for a more complete picture must be portrayed for long-term projection. Therefore, a backlog of expected business to be accumulated for a five-year period to 1950 should be used. From this figure one can arrive at an average annual demand based upon anyone's guess as to the date the war will end. At the same time, the long-term

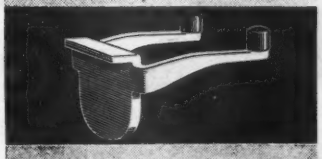
Ideal Working Conditions Sealed in with

CLARE Type "K" RELAY

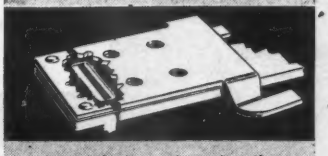
Assure Perfect Operation at Any Altitude



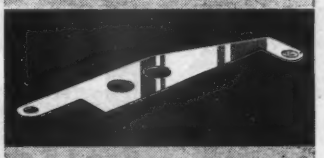
Strong, hard, long wearing Bakelite bushing insulators resist vibration and heavy contact pressures.



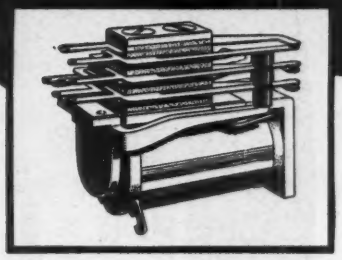
Heelpiece of magnetic metal, carefully annealed.



Hinge of "fatigueless" beryllium copper insures long life under vibration.



Nickel contact springs to which contacts are overall welded by special process.



The Clare Type "K" is a precise, small relay widely used in aircraft where inches and ounces are important.

Now Clare offers you this relay, which can be "custom-built" to your exact requirements, sealed into its own sphere of laboratory-controlled working conditions, unchanged at high altitudes or sea level. According to requirements, dry air or inert gas may be sealed in. Dimensions of sealed relay are 2 11/32" long by 1 21/32" wide.

The Clare Type "K" Relay, measuring only 1½"x 1¼-x 13/16", is especially designed for applications incident to vibration—no anti-vibration springs are needed. There are no bearings to rattle loose. Uniform armature movement is maintained by the use of a "fatigueless" beryllium copper hinge, heat-treated and designed to provide a wide margin of safety.

Permanent assembly tightness is secured by binding the spring pile-ups under hydraulic pressure and then tightening to the heelpiece. A coating of Glyptol is an added precaution.

Like all Clare Relays, the Type "K" is "custom-built" to meet your specifications. Now "custom-building" can also provide this relay with ideal conditions sealed in, to assure perfect operation at any altitude.

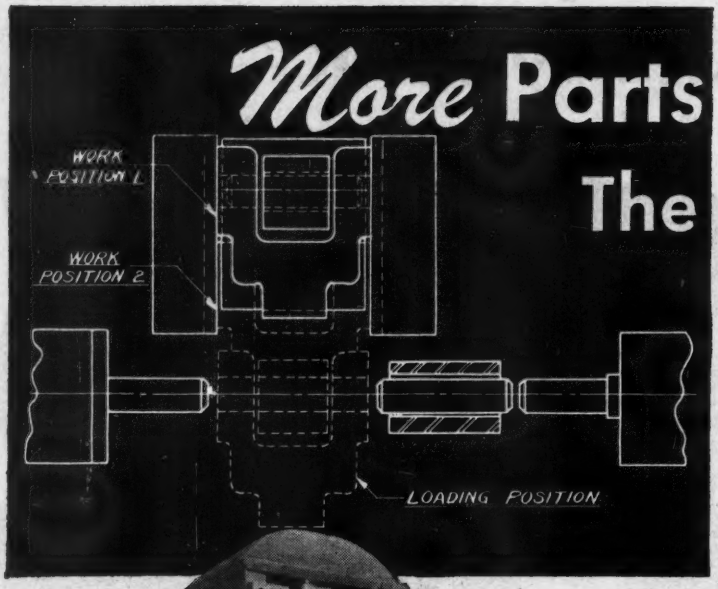
Let our engineers "custom-build" a relay to meet your requirements. Send for the Clare catalog and data book. C. P. Clare & Company, 4719 W. Sunnyside Ave., Chicago (30), Ill. Sales engineers in all principal cities. Cable address: CLARELAY.

CLARE RELAYS

"CUSTOM-BUILT" Multiple Contact Relays for Electrical, Electronic and Industrial Use

More Parts Per Broach The *American* Way—

PROVEN in war... Ready for PEACE

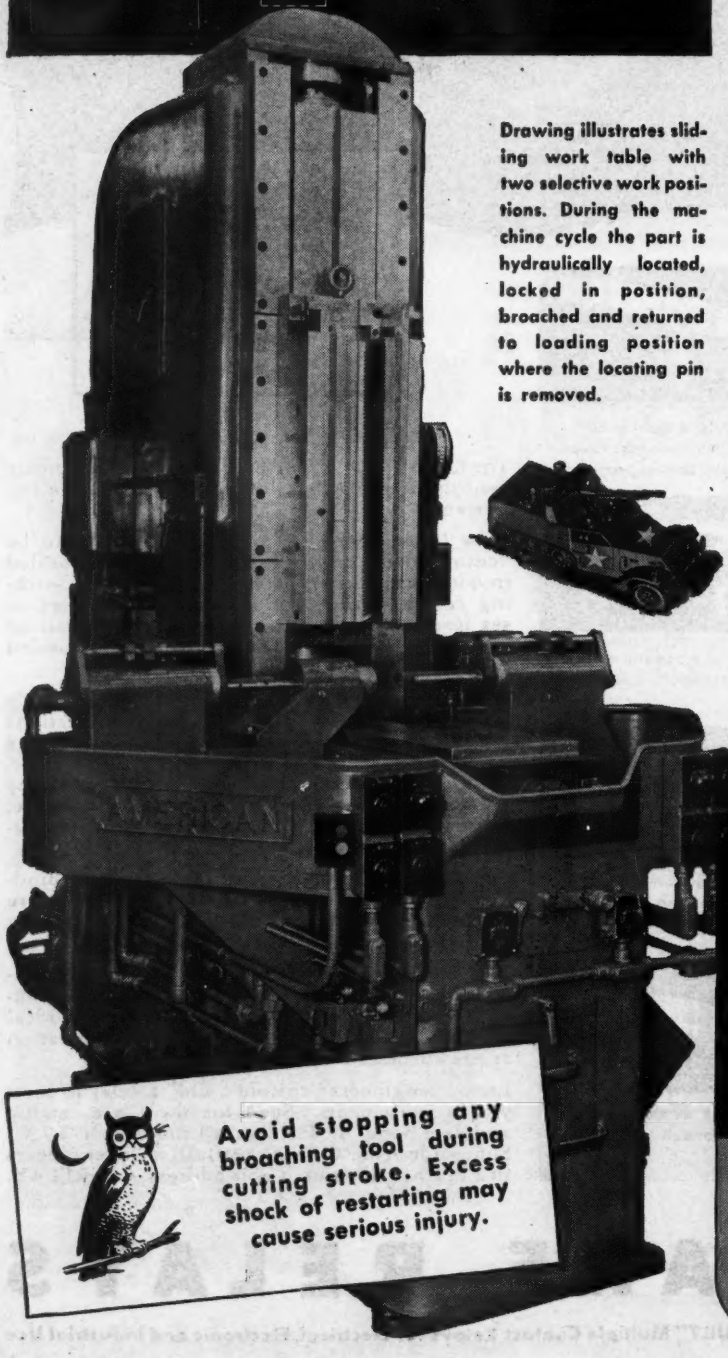


Drawing illustrates sliding work table with two selective work positions. During the machine cycle the part is hydraulically located, locked in position, broached and returned to loading position where the locating pin is removed.

Precision work at a mass production rate—*plus* the extra economy of doubled output per broach sharpening!

This is a typical example of the application of *American's* complete broaching service to a production problem. American Broach & Machine Company engineers set up this operation to finish the sides of universal joint yokes.

An American SB-42-10 surface broaching machine is used, equipped with a special receding table incorporating two selective work positions. Extra wide broaches, more than twice the part width, make possible the use of one half of the broaching surface at a time. When this half becomes dull the position may be changed so that the remaining half continues the operation. Twice the number of parts per broach sharpening are obtained, reducing production cost and time, maintaining exceptional finish and accuracy!



Avoid stopping any broaching tool during cutting stroke. Excess shock of restarting may cause serious injury.

American

BROACH AND MACHINE CO.

ANN ARBOR, MICHIGAN

BROACHING MACHINES
PRESSES
BROACHING TOOLS
SPECIAL MACHINERY

DIVISION

demand will be governed by factors that may be measured with a reasonable degree of accuracy.

Two types of markets then can be distinguished for the aviation industry: Replacement demand, and the potential new market. The crux of the situation lies in the hands of the market research man—it is he who must show the employer how great is the demand, for it is self-evident that full employment, industry by industry, must be balanced against demand. How to achieve this goal and how to hold it is market research's real job.

Precision Angle Plates

(*Continued from page* 161)

inspecting parts with compound angles. This device (Fig. 6) is an assembly of three rectangular plates made of cast iron —a base plate, a middle plate (above the base plate and hinged to it lengthwise), and a top plate hinged laterally to the middle plate. It is known as the Magnasine.

This alternate zigzag arrangement in hinging permits adjustment to allow the middle plate to open 45 deg. at an angle to the base surface and to allow the top plate to open conterminally at an angle to the middle plate surface. The compound angle determinant is fastened to the fore edge of the top plate with socket headset-screws. The angle plate has double friction locks on both plates.

Setting to an angle is accomplished by pivoting the sine bar to the specified angle and locking it in position with the wing nut on the rocker arm bolt, then setting the opposite angle merely by lifting the top angle plate and then the second angle plate until the sine bar is parallel to the base plate. After the specified angle is determined, the plates are locked in position and the job is set. In some cases the set-up is made by raising the top plate to one angle and the bottom plate to the other angle.

Ballot for Flying Boat

(*Continued from page* 121)

Where L is the payload in tons (from Fig. 1) allowing for reserve fuel amounting to 30 percent in range.

The formulas developed above are simple but accurately comparative and can be used to prepare similar analyses of other aircraft types. Employing these formulas with the arbitrary figures set forth above, we arrive at a direct *cost-per ton-mile* comparison of the economy of operation of our large flying boat and our large high-altitude land plane, each grossing 175,000 lb.†

(*Turn to page* 267)

† Two major factors inherent in airline costs have not been considered; these factors are payload factors (usually taken at 65 percent) and management and executive overhead (usually considered to be 80 percent). Therefore, if quantitative estimates are an object of the analysis, the totals computed above should be increased by a factor of:

$$\frac{1}{.65 \times .80} = 1.93.$$

CASE HISTORY
This single Kold-Hold Sub-Zero machine handles the output of expansion fit cylinder liners for four furnaces. Double the capacity of former equipment.

* *Productioneered*

BY KOLD-HOLD

Typical of Kold-Hold "Productioneering for Industry" is this experience of a large automotive and aviation manufacturer (name on request).

Faced with a tough, costly bottleneck, Kold-Hold "productioneered" a cold processing unit to fit the manufacturer's problem . . . the results were — production per hour doubled, serious bottleneck broken, closer fits attained and distortion eliminated. This is an outstanding Kold-Hold "productioneering" performance.

Maybe you have a similar "toughie." A look through our catalog, S-Z 431, may show you a machine that will fit your cold temperature application. Tell us about it and we'll help you "productioneer" your production problem. Kold-Hold machines over a range of from —100° to +200° on capacities from 2 to 400 cubic feet. If pressure and humidity control are required, we have them, too.

KOLD-HOLD

**Engineered for Production*

442 NORTH GRAND AVENUE ● LANSING 4, MICHIGAN

World's Oddest Oilcan!

An adaptation of a hypodermic needle is used to meter an *exact amount* of oil into tiny New Departure ball bearings.

This is only one of the many painstaking steps in the manufacture of perfect instrument bearings. *Why such care?*

Because ball bearings, small and large, carry a heavy wartime responsibility. Everywhere you look you'll find them doing absolutely vital work. Indeed . . . one reason for the success of Allied aircraft and other war equipment is the long life and accuracy of the ball bearings used. It is New Departure's privilege to play the lead in wartime production of ball bearings. It has an ability *to get things done,* even under the most difficult conditions. These qualities will prove increasingly helpful to all manufacturers who have ball bearing problems.

Nothing Rolls Like a Ball

NEW DEPARTURE

BALL BEARINGS

3249

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT

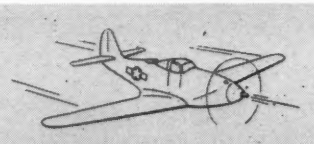
Sales Branches: DETROIT, G. M. Bldg., *Trinity 2-4700* • CHICAGO, 230 N. Michigan Ave., *State 5454* • LOS ANGELES, 5035 Gifford Ave., *Kimball 7161*

Shaped for Flight!

HERE two hollow rib-reinforced steel forgings begin to assume the subtle contours of Aeroprop propeller blades. They are being shaped on one of the many machines especially designed to mass-produce a new idea in propeller design—a propeller with hollow, rib-reinforced steel blades—a propeller unit-constructed for easy maintenance—a propeller combining all of the qualities of strength, lightness, and simplicity—a propeller less than three years old, yet famous today on every fighting front—the AEROPROP.

Today, thousands of Aeroprops are in service as thousands more move down production lines to take their places on new swarms of Allied fighters. That this has been accomplished in so short a time is further proof that America's skilled workers and production-wise machinery is an enormously resourceful and productive combination.

Today this combination is shaping Aeroprops for war, and for nothing else. When it's won these men and these machines will continue their leadership in the design and construction of modern propellers. Their job then, as now, will be to shape the progress of the conquest of the skies.



KEEP 'EM FLYING! BUY BONDS!

Aeroprop

ARMY E NAVY

In War and Peace, Propeller Production at its Best!

AEROPRODUCTS DIVISION • GENERAL MOTORS CORPORATION • DAYTON, OHIO

GM ARMS FOR VICTORY

"I got my choice of *two* bumper crops!"

Here's not one, but *two* right answers on how to get more power bits for less!

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APEX

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Fig. 3 presents this evaluation graphically. It clearly indicates that the flying boat cannot be overlooked in the development of our future international air transport equipment—for the simple reason that, in the hands of a farsighted and competent operator, it will provide the public with the cheapest form of global air transportation. For example, at the very representative range of 3,000 mi., the operating cost of the land plane will be *62 percent more per ton-mile* than that of the flying boat.

The impetus given the land plane by this war will inevitably lead to a surge or boom in land plane air transport operation following the cessation of hostilities. However, it is the studied opinion of this writer, and of others in agreement with the economic evaluation presented above, that "dollars and cents" considerations will ultimately force recognition of the flying boat's rightful place in the air transport industry.

Precipitation Static

(*Continued from page* 153)

Noise Limiter Circuits

An F-M receiver incorporates a circuit (called the "limiter") as a regular part of the receiver. It is the function of this stage to "limit" the amplitude variations of the signal entering the detector or demodulation stage. It is this stage which is primarily responsible for making the F-M receiver non-responsive to amplitude variations.

An amplitude-modulation receiver cannot have such a stage; otherwise the A-M signal would also be eliminated along with the noise. There are, however, certain forms of limiters which may be applied to an A-M receiver which will reduce the effects of sudden crashes or unusually high noise voltages which may appear along with the signal.

Most of these limiter circuits introduce some distortion. However, in many noise fields the distortion is far less objectionable than the noise. Consolidated Vultee has conducted an investigation of several types of noise limiters. The most effective for the crash type of static noise is the Wasmansdorff silencer circuit.[6]

The limiters are not particularly effective in eliminating the effects of precipitation-static. However, they do greatly aid in the operator's comfort in reducing listening fatigue and eliminating the severity of sudden crash noises.

Conclusion

Many people and organizations in this country are conducting investigations of this phenomenon. It is anticipated that there will soon be sufficient information and facts accumulated to effect a real solution to this problem.

It is probable that the result of the intensified investigation which is now being made of precipitation-static will be the development of: (1) A method of treating the airplane which will reduce the accumulation of electric charge; (2) a device for the continuous discharge or draining off of the accumulated charge in such a manner as to minimize or eliminate radio interference from this source; (3) a superior noise reduction antenna, which will probably be of the shielded loop variety; and (4) a radio receiver which is considerably less sensitive to all types of noise.

[6] Welge, V.—Investigation of Radio Noise Limiters, Consolidated Vultee Aircraft Corp. Report No. ZM-165.

Additional References

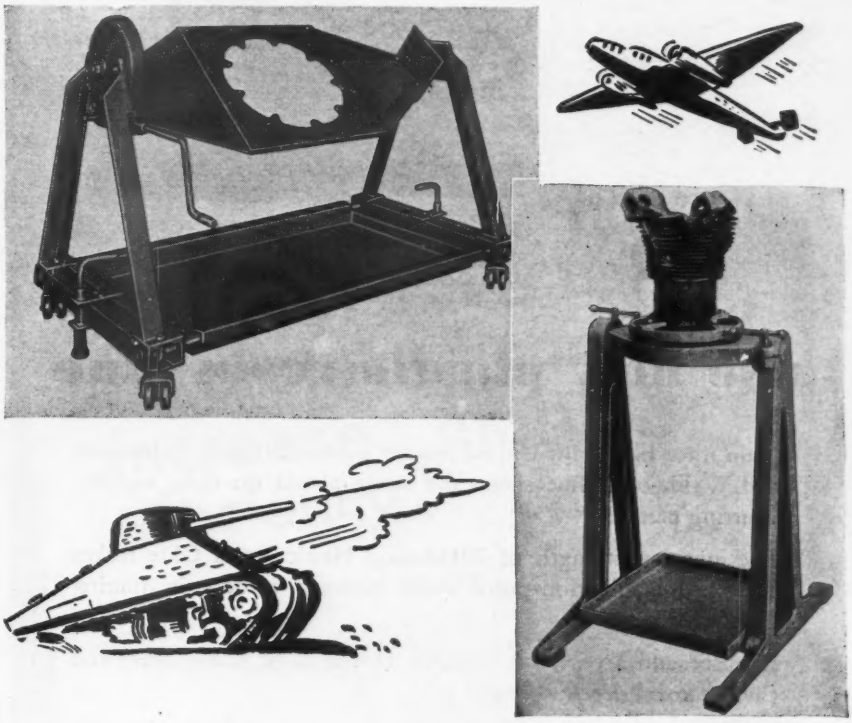
7. Grote, Reber—Cosmic Static, Proc. I.R.E., Feb., 1940.
8. Breitwieser, C. J.—Radio Noise Elimination Manual, Consolidated Vultee Aircraft Corp. Report No. ZM-062.
9. Aggers, C. V., Foster, D. E., Young, C. S.—Instruments & Methods of Measuring Radio Noise, Trans. A.I.E.E., Vol. 59, p. 179, Nov., 1940.

Air Cargo Markets

(*Continued from page* 186)

is believed can only be developed through use of commodity rates.

Over a period of years, every other form of transportation has evolved a system of commodity rates based on the service rendered, what the traffic will bear, and the need for the business. To



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● Shown above are two numbers from our complete line of aeroplane engine stands, which includes models for handling all production and servicing operations on all types of engines. The stand at the left is designed for use with interchangeable mounting plates for radial engines. The cylinder stand at the right is designed to handle engine cylinders during manufacturing and servicing operations. Further information on stands for any type of engine will be sent on request.

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date, the airlines have made rather hesitant attempts with newspapers, magazines, flowers, and a few other items; but before a backlog of experience could be accumulated, the war put such a premium on space that further steps were abandoned.

Commodity rates should be established, however, only after careful study to bring in large volumes of business with regular movement. For instance, at full rates the news magazines would have had to put such a high rate on subscriptions that the price would have been prohibitive but, under commodity rates, thousands of copies have been flown regularly by the transport lines.

In another case, foreign dealers of phonograph records have found it difficult to gage their sales requirements—a new movie may suddenly bring a quick demand for a hit tune. If additional supplies of records could be flown in economically—that is, under commodity rates—many other sales can be made. Several dealers report they feel sure that meeting such a demand would increase sales of other records by at least 50 percent if they could get enough of the hit-tune records to keep people coming into their stores. One large record manufacturer estimates his company could fly at least 250,000 lb. of records a year at rates which, it is felt, could also prove profitable to the airlines.

Moving from the strictly luxury to the semi-luxury class—a natural step toward getting in to the every day items which will be needed for the required volume—tomato growers in the Southwest, Mexico, and Cuba have already made inquiries about obtaining a commodity rate which would enable them to sell their product in the winter markets of the East at prices which will develop good volume.

These are but a few examples indicating the starting point; others include inquiries from Canadian hat manufacturers who want to sell in Venezuela and fur traders seeking Brazilian and Argentinian markets.

Perhaps the greatest value which can come from commodity rates is their ability to help balance the directional flow of goods previously discussed. As has been shown, it is only between the United States and Europe that any equality of movement can be anticipated, for between the United States and Latin America the movement has been twice as heavy to the south as it has toward this country. Careful research will be required to locate products which can move by air at lower price levels and, although it is too much to hope that the traffic can be equalized completely, commodity rates will help to fill some of the empty space on return runs.

With the experience in design and engineering gained during the last few years we can expect that new equipment will be more efficient, resulting in lower operating costs which, in turn, will warrant lower rates. A great deal of business can be obtained through lowering the rates where such reductions will enable new

commodities to move by air, rather than through trying to increase the movement of goods already being flown. The days when business "came in over the transom" are over; we are approaching a time when the airlines must go out vigorously for new business and hold it through sales and service.

Geometry for Lofting

(*Continued from page* 164)

canted spar. This information is required in order to correctly locate a clearance hole.

Equations of the control cable $Y = 4.2\ X - 26$

$Z = 0.3\ X + 7.5$

Equation of the canted spar: $0.204\ X + Y - 0.080\ X - 80 = 0$

Now by substituting the equations of the cable into the equation of the spar the unknown value "*X*" may be found.

$$0.204\ X + 1\ (4.2\ X - 26) - 0.080\ (0.3\ X + 7.5) - 80 = 0$$

$$0.204\ X + 4.2\ X - 26 - 0.024\ X - 0.600 - 80 = 0$$

$$4.380\ X = 106.600$$

$$X = 24.338$$

In order to find the "*Y*" and "*Z*" values, substitute the "*X*" value just obtained into the original equations of the control cable.

$$Y = 4.2\ (24.338) - 26 = 102.220 - 26 = 76.220$$

$$Z = 0.3\ (24.338) + 7.5 + 7.301 + 7.5 = 14.801$$

In our last article (Part II, Apr. AVIATION), we demonstrated the manner in which a cover sheet was developed. This cover was for the lower surface of the wing of the P-61 *Black Widow*. In obtaining the flat pattern layout we used coordinates of points obtained by the intersection of canted planes and lines. Now we may show how these points were determined:

As the P-61 was developed, a series of equations for the various structural members were accumulated. Among these were the equations for the rear spar, flap closing channel, canted flap station, and other canted stations. These equations had seen much valuable use long before the cover sheets were required and had been kept on file for future use in tooling data books. These equations were—

Lower ML rear spar

$Y = -0.161625\ X + 108.836$

$Z = 0.01773\ X - 10.594$

Lower ML flap closing channel

$Y = -0.19994\ X + 133.998$

$Z = 0.01555\ X - 9.271$

Canted flap station

$Y = 4.836853\ X - 621.277$

Double canter station

$X - 0.168372\ Y - 0.005543\ Z - 177.008 = 0$

By using these equations together in simultaneous solutions we were then able to establish the coordinates of the necessary corner points.

Procedure: Find the intersection at wing station 139 rear spar intersection.

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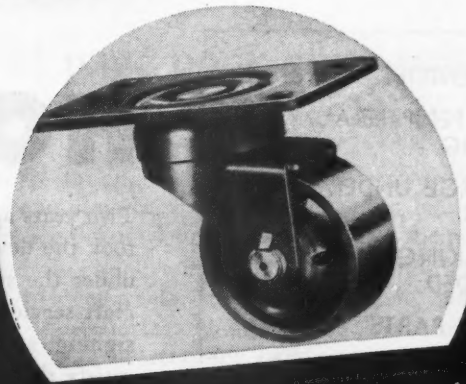

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Look for the name AIRCRAFT STANDARD PARTS CO. on "Aero-Seal" Hose Clamps. It appears on the wing of the thumb screw, and the housing is also stamped with the type number and "Aero-Seal". On the band and the wing you will find the part number and AN number.

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AIRCRAFT Standard PARTS CO.

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$X = 139$
$Y = -.161625\ (139) + 108.836 = 86.370$
$Z = .01773\ (139) - 10.594 = -8.130$

By this same method the coordinates for the point on the flap closing channel were found.

Intersection of the double canted station and the lower ML of the rear spar:

$$X - 0.168372\ (-0.161625\ X + 108.836) - 0.005543\ (0.01773\ X - 10.594) - 177.008 = 0$$

$$1.027115\ X = 195.364$$
$$X = 190.206$$

By substituting this value into the equations of the spar ML we can then find the Y and Z values.

$$Y = -0.161625\ (190.206) + 108.836 = 78.094$$
$$Z = 0.01773\ (190.206) - 10.594 = -7.222$$

Once again this method was used at the flap closing channel.

The intersection of the rear spar and the canted flap station was determined by a manner similar to the intersection of two lines in plan view.

$$Y = 4.836853\ X - 621.277$$
$$Y = -.161625\ X + 108.836$$
$$0 = 4.998478\ X - 730.113$$
$$X = 146.067$$
$$Y = -0.161625\ (146.067) + 108.836 = 85.228$$
$$Z = 0.01773\ (146.067) - 10.594 = -8.005$$

By now it should be quite apparent to the reader that the use of analytic geometry in the development of aircraft is a very versatile tool, not only of value to the loftsman but also to the engineer, tool designer, and liason men. It may be used by anyone with a basic knowledge of mathematics.

"Peashooters"

(*Continued from page* 189)

track down difficulties reported by the pilot when, in fact, the pilot had been improperly setting his fuel mixtures or cooling flaps, or merely didn't know when to use the fuel booster pump.

"Excessive engine roughness" is a common pilot complaint, but it just happens that after a couple of hundred hours an engine doesn't run like a newly overhauled job. That certainly doesn't mean it should be pulled off alert status.

In brief, the fighter pilot should *know* his airplane. He should strive to be as good a troubleshooter as he is a pilot. One of the simplest and quickest ways to achieve this end is to be inquisitive. When trouble develops and is corrected by the crew chief, the pilot will profit if he ascertains from the crew chief exactly what the difficulty was—and it's a good idea for the pilot to learn what caused it and how it was corrected. If it should happen again, the pilot would be able to recognize it, refer the precise trouble to the crew chief, and get the airplane back on alert with a minimum of effort. A valuable by-product of this procedure is the building up, between pilot and crew chief, of a personal interest in each other's work. An inevitable improvement in achievement results.

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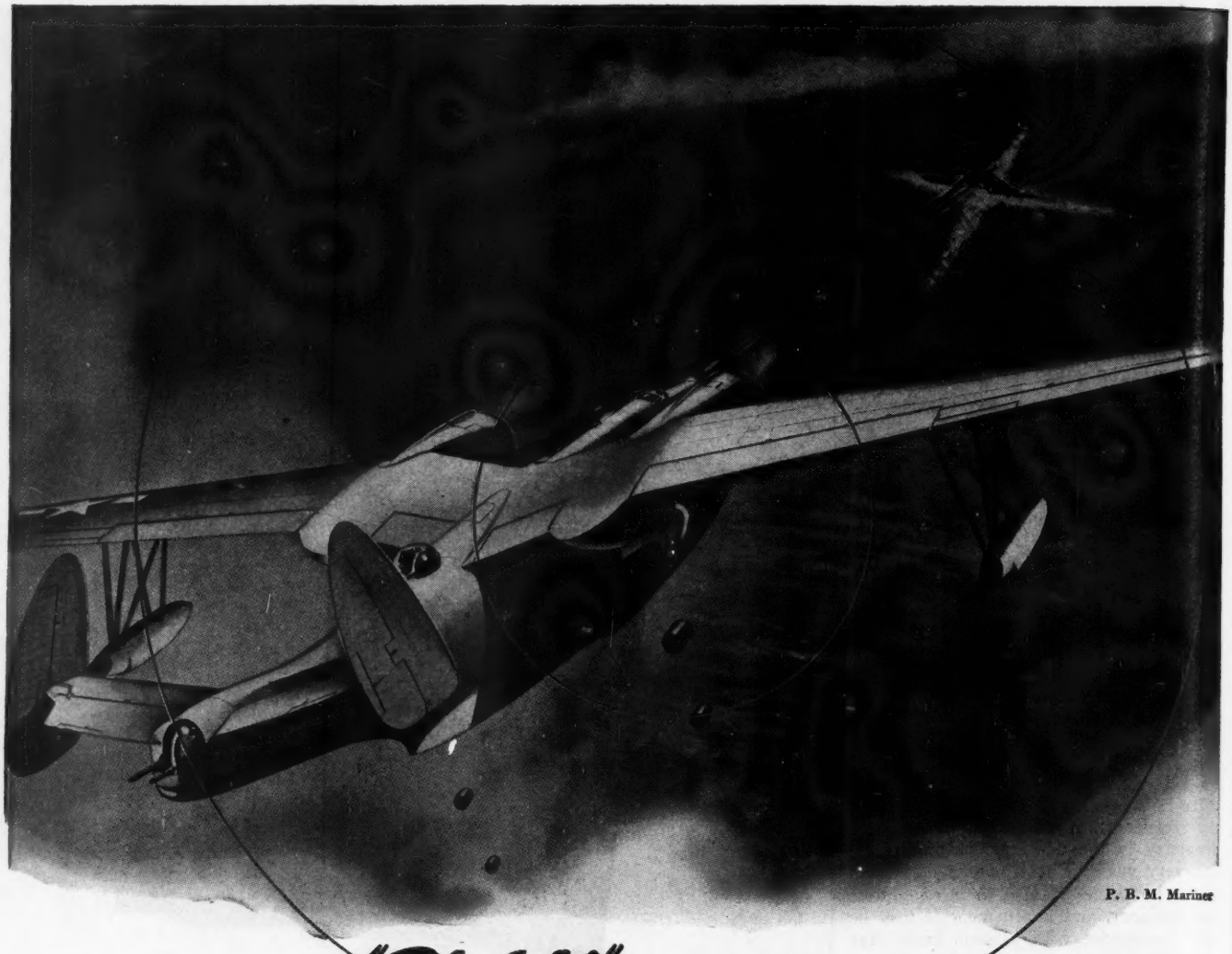

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Bomb bay doors must open quickly and smoothly without jarring . . . *and close without slamming.* Holtzer-Cabot designed a special gear motor to meet these performance requirements which is, today, helping bombardiers blast the enemy.

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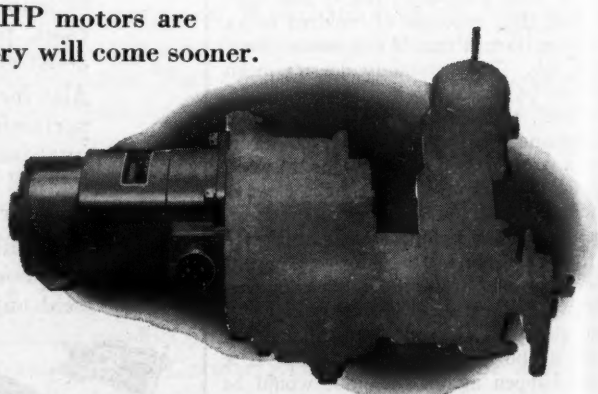

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On countless occasions, Gen. Ennis C. Whitehead of the 5th Air Force has said that it was the close cooperation of each individual that was winning the war—and the close cooperation of the fighter pilot and his crew chief is an excellent example of what he means.

Computing Airspeed

(*Continued from page* 155)

as an approximation when its value is unknown.

Purpose of this article is the presentation of the above-mentioned graphic simplifications. No attempt has been made to discuss sources of error in true airspeed computations due to instrument and pitot-static head position errors affecting both altimeter and airspeed meter readings. In order to compute true airspeed accurately, it is, of course, necessary to measure indicated airspeed and pressure altitude accurately. Derivations of the nomographs and curves presented have been omitted. Thorough-going theoretical treatment of the principles involved have been published in NACA Technical Note No. 616, "The Measurement of Air Speed of Airplanes," by F. L. Thompson, and "Empirical Equations and Nomograph," by Dale S. Davis, McGraw-Hill Book Co., 1943.

Airfoil Pressure

(*Continued from page* 144)

Analyzing the Data

It has become standard practice to express all force data obtained from wind tunnel tests in non-dimensional coefficients of the form—

$$C_F = \frac{F}{qS} \qquad (10)$$

where: F is the force.
q is the free stream dynamic pressure.
S is the area.

In the case of the pressure distribution, the element of force is pds or $(p_L - po)\ ds$, where ds is the element of length under consideration. Regarding the area S, the primary consideration is that of two dimensional flow, but physical reality is retained in the problem by considering a unit span so that S now becomes c (the chord length) times unity.

Referring now to the normal force per unit span F_y', and recalling that—

$$F_y' = pdx$$

$$\text{then } C_n = \frac{Fy'}{qc}\int\frac{p}{q}\frac{dx}{c} = \frac{1}{c}\int\frac{p}{q}\,dx \qquad (11)$$

where dx is the chordwise distance from the leading edge, and C_n is the normal force coefficient.

Similarly the chord force is given by—

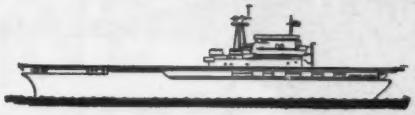
$$C_c = \frac{1}{c}\int\frac{p}{q}\,dy \qquad (12)$$

where dy is the vertical distance from the chord line.

Moments are also reduced to non-dimensional coefficients of the form—

$$C_m = \frac{qS_c}{M} \qquad (13)$$

WORTHY OF AMERICA'S FIGHTING SHIPS



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In the Ready Room on an Aircraft Carrier, in most rooms on our Navy's ships where furniture is used you find fireproofed upholstery. The Navy Bureau of Ships' specification for fireproofed seat upholstery is fulfilled by the quality of our Fireproof Naugahyde.

Years before Pearl Harbor our Research and Development Departments had already evaluated the plastics and synthetic resins which could be used to improve rubber coated fabrics. Because of this preliminary work we were able to almost immediately convert from rubber to plastic Naugahyde for upholstery in tanks, trucks, buses, airplanes, ships and other mobile equipment.

Today new types of coatings developed during the war are being applied to all kinds of fabrics—cotton, rayon, nylon, fiber glass—to provide the many specialized coverings for the war in general.

These war developments and more now being perfected in our laboratory are important to you, as a user of Naugahyde. Out of war, will come a better Naugahyde, better made than ever, to serve you in meeting the needs of an America at peace.

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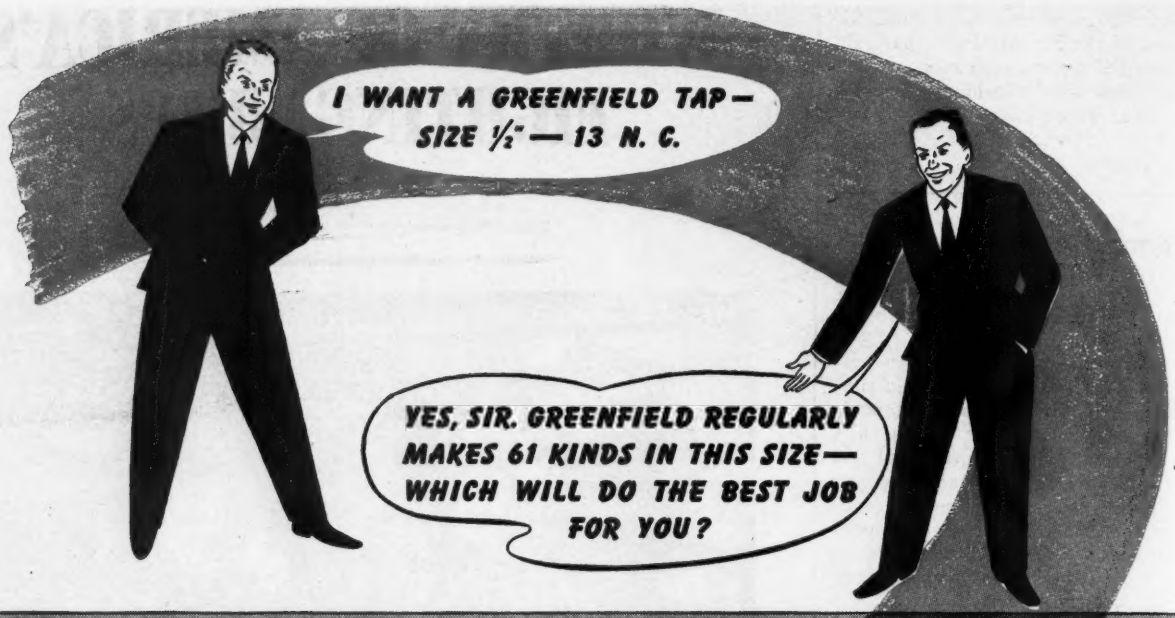
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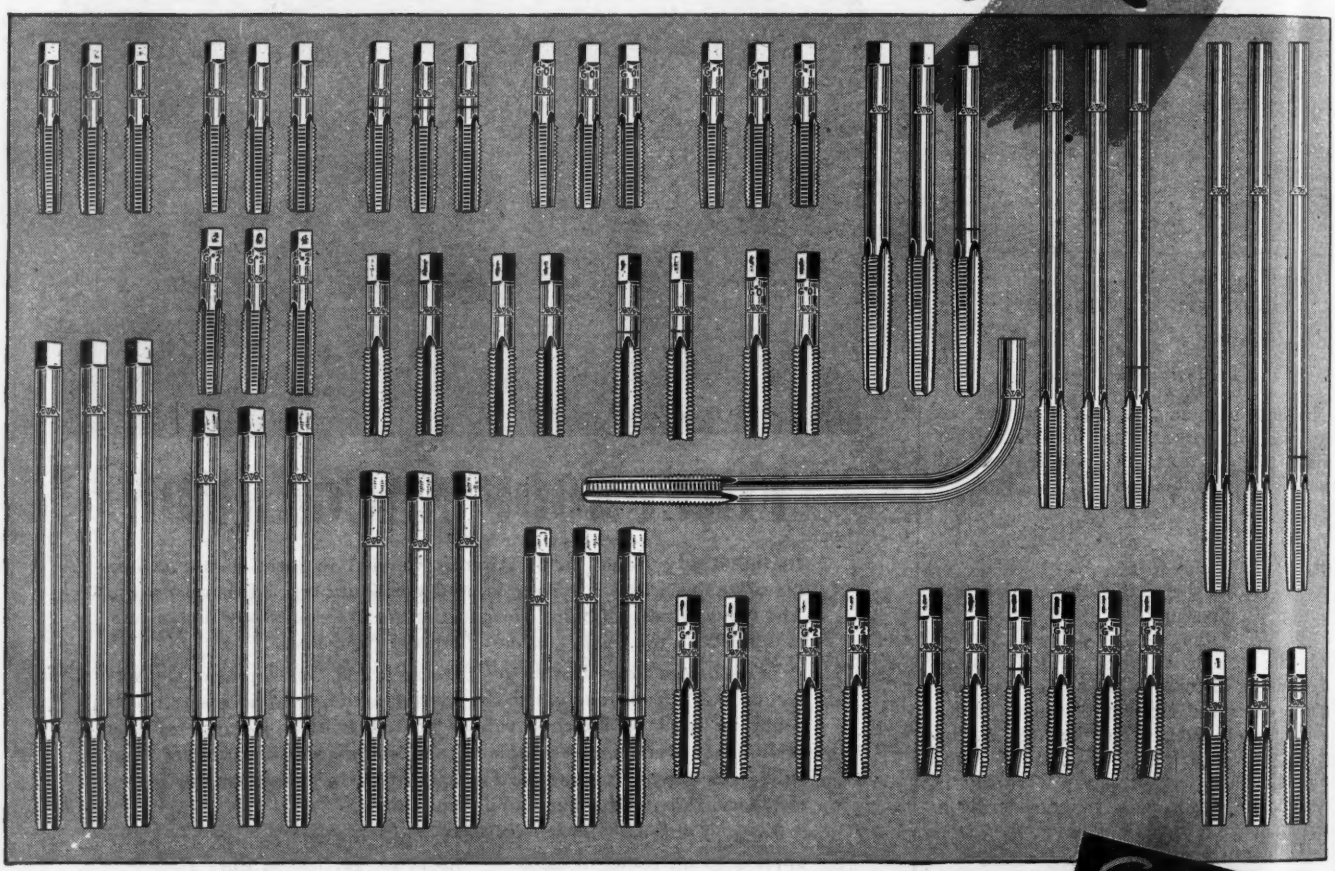
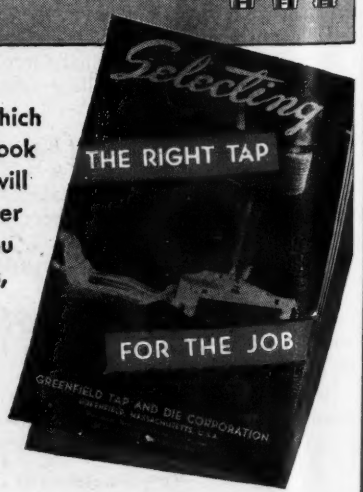


IT'S TRUE. Shown above are the 61 different kinds of ½"—13 N. C. Taps which "Greenfield" lists in its catalog, not including special "Maxi" finish taps. Many look identical, but each has its own particular qualities and usefulness. . . . Which one will do the best job for you? That is a "$64 question" that Greenfield helps you answer in its new booklet "Selecting the Right Tap for the Job." If you need more help, you can call on Greenfield's staff of expert screw thread engineers for recommendations, or ask a Greenfield field service engineer to call.



GTD GREENFIELD
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where M is the moment. Consistent with the convention of taking airfoil moments about the quarter-chord point, the expression for the quarter-chord moment coefficient becomes—

$$C_{mc4} = \frac{1}{C^2}\left[\int \frac{p}{q}\left(\frac{C}{4} - x\right)dx + \int \frac{p}{q}\, y\, dy\right] \quad (14)$$

In obtaining the net static pressure, it becomes necessary to refer all orifice readings to some reference level. Choice of this level, and the ensuing derivation of convenient coefficients with which to present the data, has been the source of some confusion. Various writers have introduced different nomenclature with which to present the data, however the implications of each are identical.

If the free stream static pressure is taken as the reference level, then the net static pressure is merely—

$$p = p_L - p_o \quad (15)$$

where: p_L is the local static pressure.
p_o is the free stream static pressure.

The definition of the pressure coefficient P, is—

$$P = \frac{p}{q} = \frac{P_L - P_o}{q} \quad (16)$$

Some writers refer to the pressure coefficient as $\Delta p/q$ and others as C_p. Choice of the form is arbitrary, the important point being that value represented by each form is identical with the others.

In some instances,[4] the orifice readings are referred to free stream total head, for which case—

$$\delta p = H - P_L \quad (17)$$

or $$P_L = H - \delta p \quad (18)$$

The value of H for the undisturbed stream is—

$$H = P_o + \delta \quad (19)$$

Substituting this in the expression for p, and solving—

$$P_L - p_o = q - \delta p \quad (20)$$

The pressure coefficient P is again defined by—

$$P = \frac{P_L - P_o}{q_o} = 1 - \frac{\delta p}{q_o} \quad (21)$$

In some instances, the data are presented in terms of the square of the velocity ratio— $\left(\frac{V_1}{V_o}\right)^2$

which is called S. The relation between P and S is easily established by equating Bernoulli's Equation at some point on the airfoil to some point in the free stream, viz—

$$P_o + q_o = p_L + q_L \quad (22)$$

from which

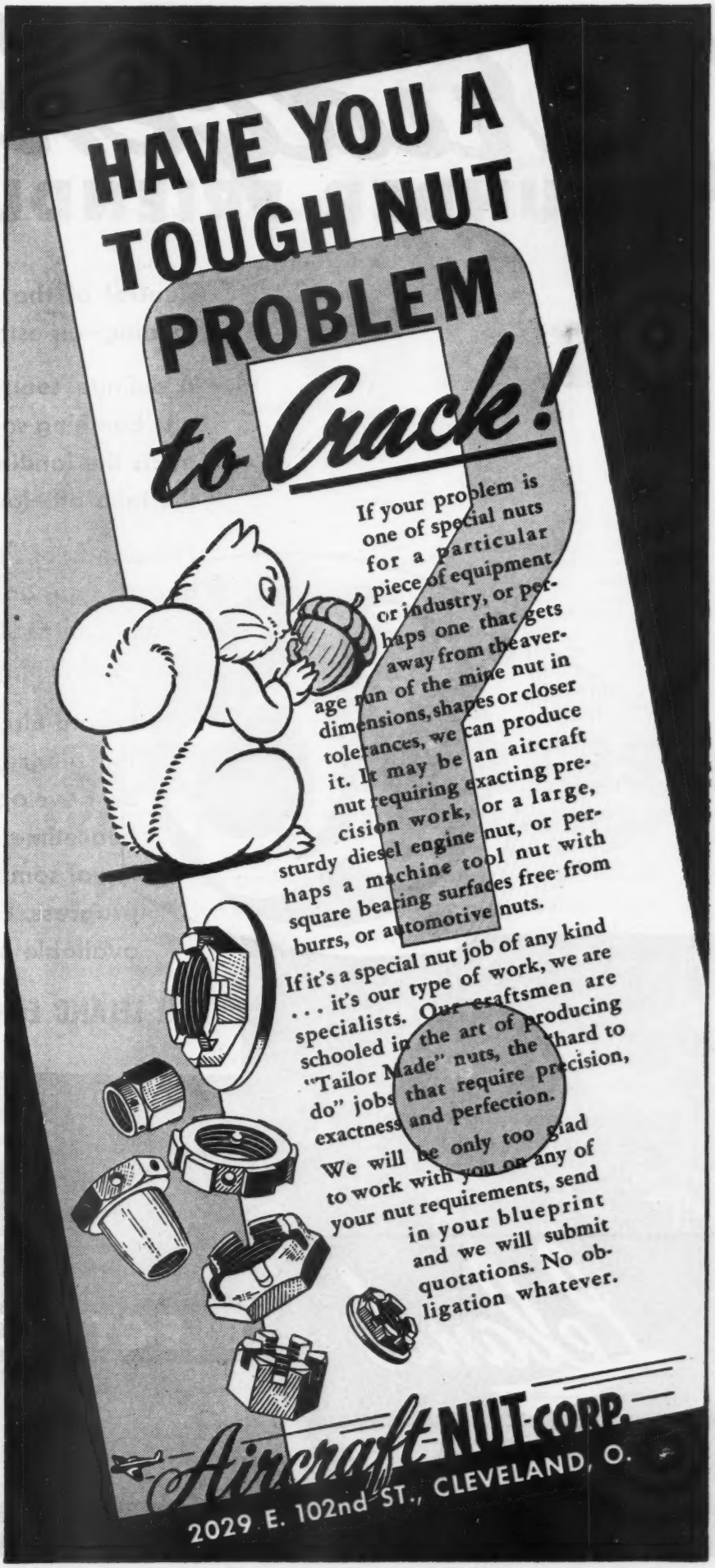
$$P_L - p_o = q_o - q_L \quad (23)$$

Dividing by q_o,

$$(P_L - P_o)/q_o = 1 - \frac{q_L}{q_o} = 1 - \frac{P_L}{p_o}\left(\frac{V_L}{V_o}\right)^2 = P \quad (24)$$

For incompressible flow (which exists in the majority of testing), the density is constant throughout the flow and cancels

[4] cf. T.R. 563.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If your problem is one of special nuts for a particular piece of equipment or industry, or perhaps one that gets away from the average run of the mine nut in dimensions, shapes or closer tolerances, we can produce it. It may be an aircraft nut requiring exacting precision work, or a large, sturdy diesel engine nut, or perhaps a machine tool nut with square bearing surfaces free from burrs, or automotive nuts.
If it's a special nut job of any kind . . . it's our type of work, we are specialists. Our craftsmen are schooled in the art of producing "Tailor Made" nuts, the "hard to do" jobs that require precision, exactness and perfection.
We will be only too glad to work with you on any of your nut requirements, send in your blueprint and we will submit quotations. No obligation whatever.
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out of the above expression to give—

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All publications of the NACA present pressure distribution data as plots whose coordinates are either P, S, or p/q against percent chord. Where auxiliary surfaces, such as flaps or ailerons, are tested, the loading on these surfaces may be given parallel and perpendicular to their chord lines or parallel and perpendicular to the chord line of the wing proper. In actual practice, the data are taken by visual observation or by simultaneous recording of all manometer tubes. The latter is accomplished by photographing the manometer board or by placing a sheet of photostat paper behind the manometer tubes and exposing the arrangement to a strong light.

A typical record taken by the photostat method is shown in Fig. 8. The total head tubes (labeled Z) are used as a reference level, and all measurements are referred to them. Distance in inches from the reference level to the meniscus of the pressure tubes is divided by the dynamic pressure (in corresponding inches of the same manometer liquid). This is equal to $\delta p/q$ and $1 - \delta p/q = P$, the pressure coefficient. P is then plotted against x/c for normal force coefficients or y/c for chord force coefficients, where x and y are the coordinates of the orifice locations measured from the leading edge and chord line respectively.

Review of Patents

(*Continued from page* 192)

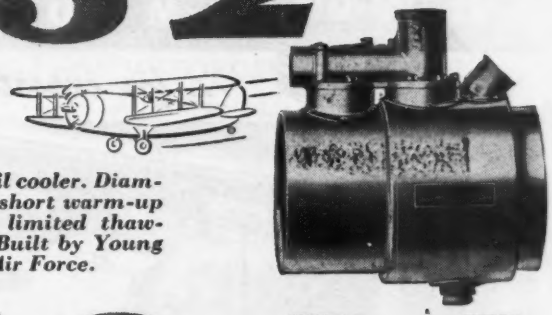
scribes arrangement in which these features result from a cable connection between movable element of accumulator and lift system. Invention associates auxiliary lifting jack with main lifting jack. Former communicates with accumulator, as main jack, but is kinematically connected to retractable undercarriage to introduce, at every instant, desirable pressure compensation in hydro-pneumatic circuit.—2,336,794, filed Feb. 10, 1941, patented Dec. 14, 1943, R. L. Levy, assignor to Societe d'Inventions Aeronautiques et Mecaniques S.I.AM., Fribourg, Switzerland.

New Throttle Control Device is designed to govern engine to achieve constant power output by causing throttle to be responsive, in its position, to liquid fuel flow of engine. Engine power is controlled by maintaining as a constant the amount of liquid fuel fed to engine carburetor, or to any other fuel-air proportioning device which may be used. Device is stated to be particularly applicable to aircraft engines.—2,336,800, filed July 15, 1941, patented Dec. 14, 1943, E. F. Pierce, assignor to Wright Aeronautical Corp.

For Mechanisms of retractable landing gears, new patent particularly concerns valve adapted for use in shock absorbing struts of such gears. Provided is vent-closing valve with automatic means for closing vent when gear is completely retracted. Vent is open at all times except when strut is fully collapsed. Means of closing vent is arranged to operate along with retracting and extending mechanism of gear.—2,336,823, filed Jan. 31, 1941, patented Dec. 14, 1943, F. A. Wedberg and F. Lakowitz, assignors to Curtiss-Wright Corp.

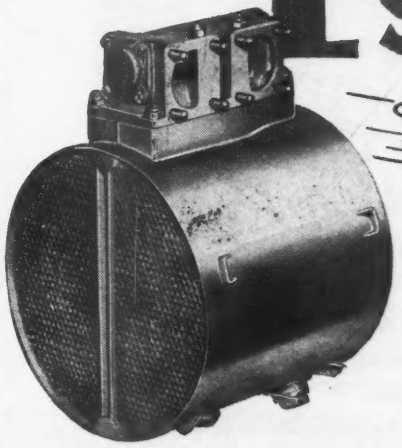
Engine-Propeller Control has been devised for operation where a supercharged engine drives a governor-controlled variable-pitch propeller. Arrangement is designed for simultaneous regulation of engine horsepower and propeller pitch,

1932



A pioneer aircraft oil cooler. Diameter 5 inches, with short warm-up "muff" indicating limited thaw-out requirements. Built by Young for the U.S. Army Air Force.

1944



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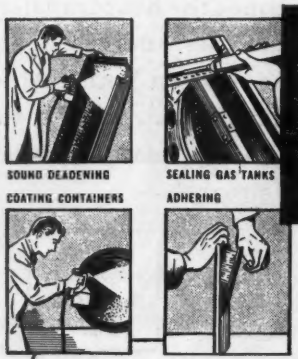

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especially for particular airplane maneuvers such as takeoff, climb, and cruising. Means is also provided for simultaneously regulating engine intake manifold pressure and propeller-pitch controlling governor in order that a desired engine performance for a particular maneuver may be repeated each time specific maneuver is made.—2,336,844, filed Dec. 29, 1939, patented Dec. 14, 1943, R. S. Buck, Assignor to United Aircraft Corp.

Aircraft Fire Extinguishing System. Here, primary object is to reduce complication and labor required for installing fire extinguishing systems in aircraft, also to minimize weight of system when installed. Arrangement calls for delivery of fire-fighting gas to engine compartments through a system of discharge piping, of requisite diameter, running in shortest possible course from source to each compartment, that is, as directly as internal wing structure of craft will permit.—2,336,942, filed Sept. 16, 1942, patented Dec. 14, 1943, C. H. Lindsay, assignor to American-La France-Foamite Corp.

Aviation Mask. This is an oronasal high-altitude breathing mask having breathing chamber adapted to enclose mouth and nose of wearer with inclusion of microphone. Latter is located immediately in front of mouth of wearer. This mask's breathing valves are symmetrically positioned in a transverse line on either side of microphone casing, transverse valves being placed for easy balanced breathing. A porous material, such as sponge rubber, is employed in connection with double valve openings.—2,336,979, filed Apr. 19, 1941, patented Dec. 14, 1943, W. M. Boothby and A. H. Bulbulian.

Parachute Pack Invention concerns development of pack and container in which suspension lines of a parachute are prevented from being thrown over or about canopy, thus fouling it. To achieve this result, there are incorporated means for retaining skirt of canopy in place adjacent to base of pack and over suspension lines until upper portion of canopy has been drawn out to nearly its full length. Thereafter, skirt of canopy is released, and suspension lines are only drawn from retainers when canopy is so extended that these lines cannot throw-over to foul canopy.—2,337,169, filed Oct. 9, 1941, patented Dec. 21, 1943, F. Smith, assignor to Pioneer Parachute Co.

Stabilizing Means for Rotary Craft. This is development to attain substantial equality of torque of rotors (in craft having a pair or more of rotors) at least under normal flight conditions. Specified is balance gear of differential type for use in conjunction with system for controlling pitch of rotors. Means are provided permitting rotors to continue turning in event of engine or transmission failure so that sufficient lift is maintained to allow craft to be landed safely. This is accomplished through arrangement for disconnecting engine from both rotor transmissions.—2,337,570, filed Apr. 24, 1940, patented Dec. 28, 1943, C. G. Pullin, assignor to Autogiro Co. of America (G. & A. Aviation Corp.).

Automatic Pilot Development concerns use of detachable card for gyro turn units of such mechanisms. Particularly specified are improvements in construction and assembly of upper card of turn units. Here, detachable card is so constructed, with respect to assembly, that it may be readily installed after remaining assembly has been completed, thus obviating possibility of damage or destruction of card, which is stated to be a common risk in conventional practice of securing card to parts prior to assembly.—2,337,602, filed Oct. 21, 1942, patented Dec. 28, 1943, R. M. Heintz, assignor to Jack & Heintz.

Intercooling Problems

(*Continued from page* 192)

be about 300 deg. F. under standard atmospheric conditions. Even if detonation did not prohibit such temperatures, the loss in thermal efficiency of the engine and the loss in efficiency of the engine-stage supercharger would do so. In such a case, the only alternative to some form of charge-air cooling is severely reduced power output.

On the other hand, consider a transport

designed to cruise at 25,000 ft. and employing both auxiliary- and engine-stage supercharging to attain this critical altitude. If a pressure out of the auxiliary-stage supercharger of as 23 inches of mercury is required for, say, the power to be used in climbing to 25,000 ft., the resulting carburetor temperature will be about 140 deg. F. compared with an outside air temperature of —30 deg. F. Now this temperature might easily be below the detonation limit at the climb power, so that intercooling could be omitted without reduction of manifold pressure. If intercooling were used, an initial temperature difference between engine and cooling air of 170 deg. F. is available, so an engine air temperature drop of 70 deg. could readily be obtained (40 percent intercooler "effectiveness"). This would produce a gross gain in engine power of the order of 7 percent. Even though the net gain would be somewhat less because of the weight and drag of the intercooler, the improvement in rate-of-climb at this altitude would be substantial.

Consider, however, the cruising condition. A carburetor pressure of 18 inches of mercury would probably produce the cruising power desired. Without intercooling the carburetor air temperature would be only 80 deg. F. compared with a detonation temperature of perhaps 150 deg. F. Intercooling could reduce the 80 deg. temperature to 40 deg. F. or less, but this temperature reduction is certainly unnecessary, and would be of no advantage to the transport unless it resulted in reduced specific fuel consumption since the additional power is not needed.

With the fuels of reduced volatility now available, difficulty with poor vaporization is likely to be encountered at low mixture temperatures. The trouble takes the form of condensation of the fuel in the manifold and on spark plugs, cylinder walls, etc., resulting in excessive leanness, low effective anti-knock, and fouling of the plugs. There is, accordingly, a trend toward the use of higher carburetor air temperatures. Under these conditions it is doubtful whether lower fuel consumptions would result from lower carburetor air temperatures attainable with intercooling even if such temperatures were usable in cruising. When the drag and weight of the intercooler installation is considered, it is apparent that such an installation may well be detrimental at cruising power.

Such being the case, the question arises as to whether it is worth-while in transport operation to risk reduced efficiency in many hours of cruising in order to have available more rate-of-climb at altitude.

It will be well to defer a specific answer to the question of when to employ charge-air cooling with the conclusion merely that high carburetor air temperatures in some flight conditions do not necessarily mean that charge-air cooling is desirable.

How Much Charge-Air Cooling?

Next, let us take up a problem closely related to that just considered: if charge-

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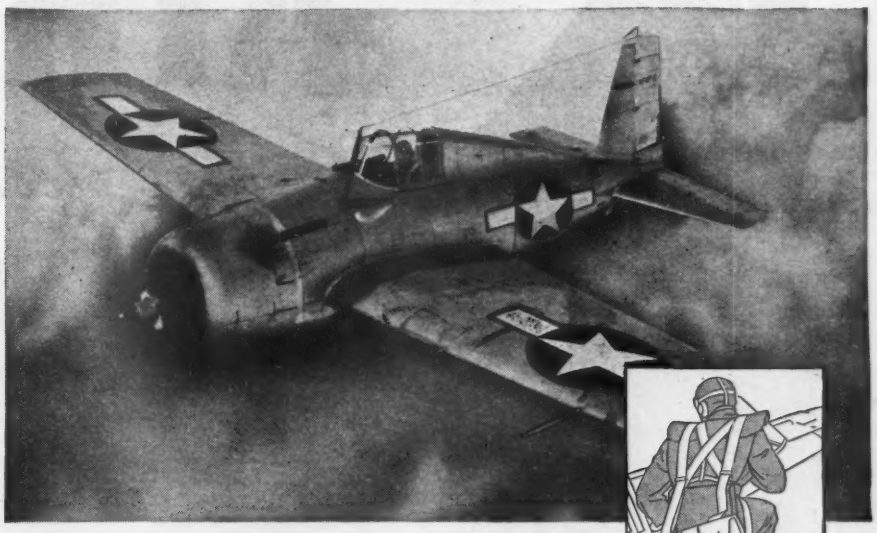

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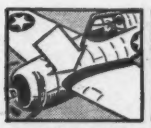

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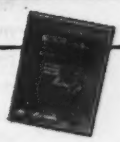

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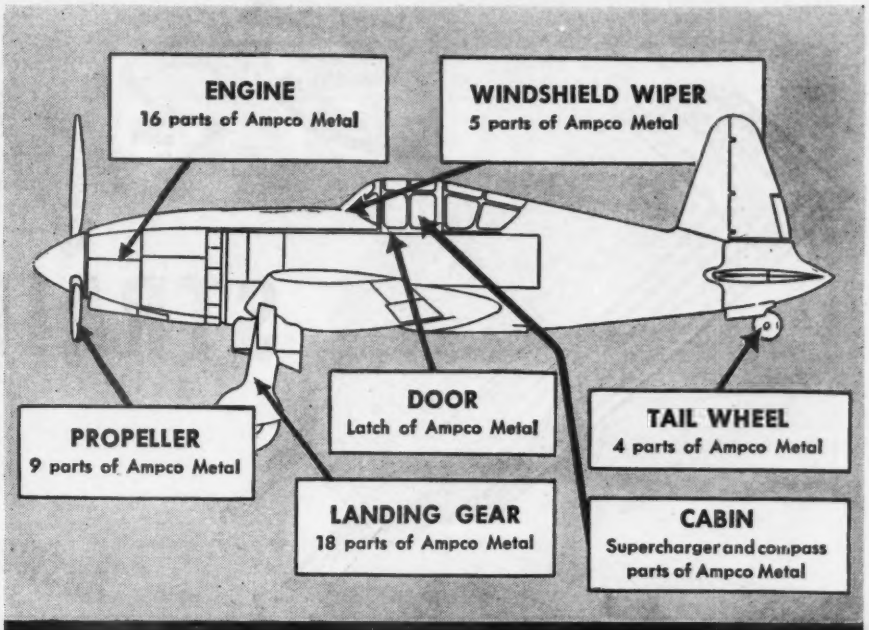
air cooling is to be employed, how much cooling should be attempted? The answer lies between two limits. The minimum amount of cooling is that which will provide a carburetor air temperature just low enough to avoid detonation under the most critical condition. The maximum possible amount of cooling is really no limit, since it requires infinite intercooler size; it provides a carburetor air temperature equal to the atmospheric temperature increased by dynamic heating.

In arriving at the minimum intercooler size, it is found that the limit is not absolute; it depends upon the selection of the *most critical condition.* In the case of fighter airplanes, there is little question that the power used should be the maximum permissible from the engine, and the altitude should be the maximum obtainable with the supercharger. Whether the atmospheric temperature used should correspond to the hottest day likely to be encountered or to an average day is debatable, but with military airplanes the decision is out of the hands of the airframe designer since it is specified by the procuring agency. With commercial airplanes there is not only the question of atmospheric conditions, but also the question of what power and altitude to use. As we saw earlier, it probably will not be desirable to cool maximum power, but only a typical power condition.

Now, the determination of the optimum intercooler size for a particular condition is a straightforward problem which proceeds along well-established lines, under assumptions which will be discussed later. The important point is that the optimums intercooler is purely of academic interest; the size of intercooler which results in the optimum airplane is generally the smallest size which will squeeze by the most critical necessary design condition. This results from the fact that for any particular design condition, the optimum intercooler is somewhat larger than the one that will just meet that condition. The minimum intercooler for the most critical condition is however, generally larger than the optimum for the *typical* operating condition. If the optimum cooler were selected for the most critical condition, a double penalty would accrue in the typical operating condition. The minimum coole- for the most critical condition is already larger than the optimum for the typical condition, and the optimum for the most critical condition is larger still. Therefore, the only usefulness in calculations of the optimum intercooler is to make sure that the optimum cooler for the typical condition is not larger than the minimum required for the most severe condition which must be met.

For example, in the case of fighter, the typical condition may well be taken as the maximum power at the critical altitude under standard atmospheric conditions, and the most severe condition as the same power and altitude with maximum summer temperatures. Of course, the carrying of the larger cooler which will result from these conditions for the long distance now required of fighters will exact a severe penalty in weight, but this must be accepted since the pri-



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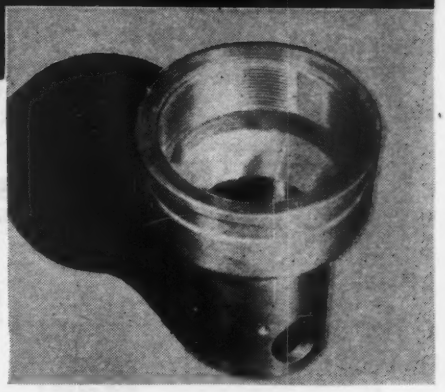

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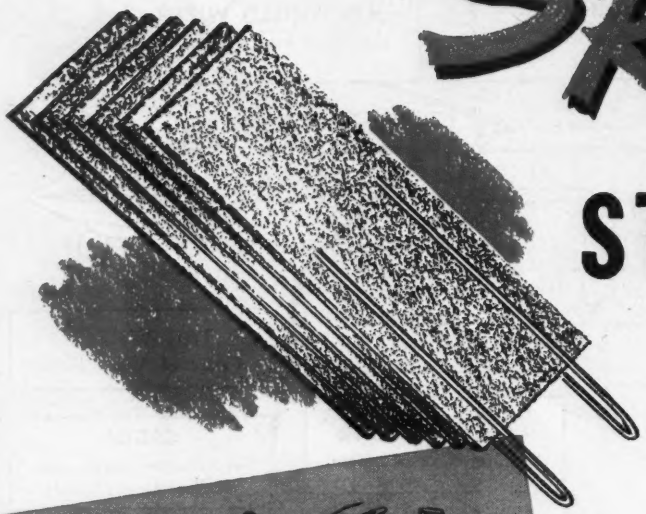

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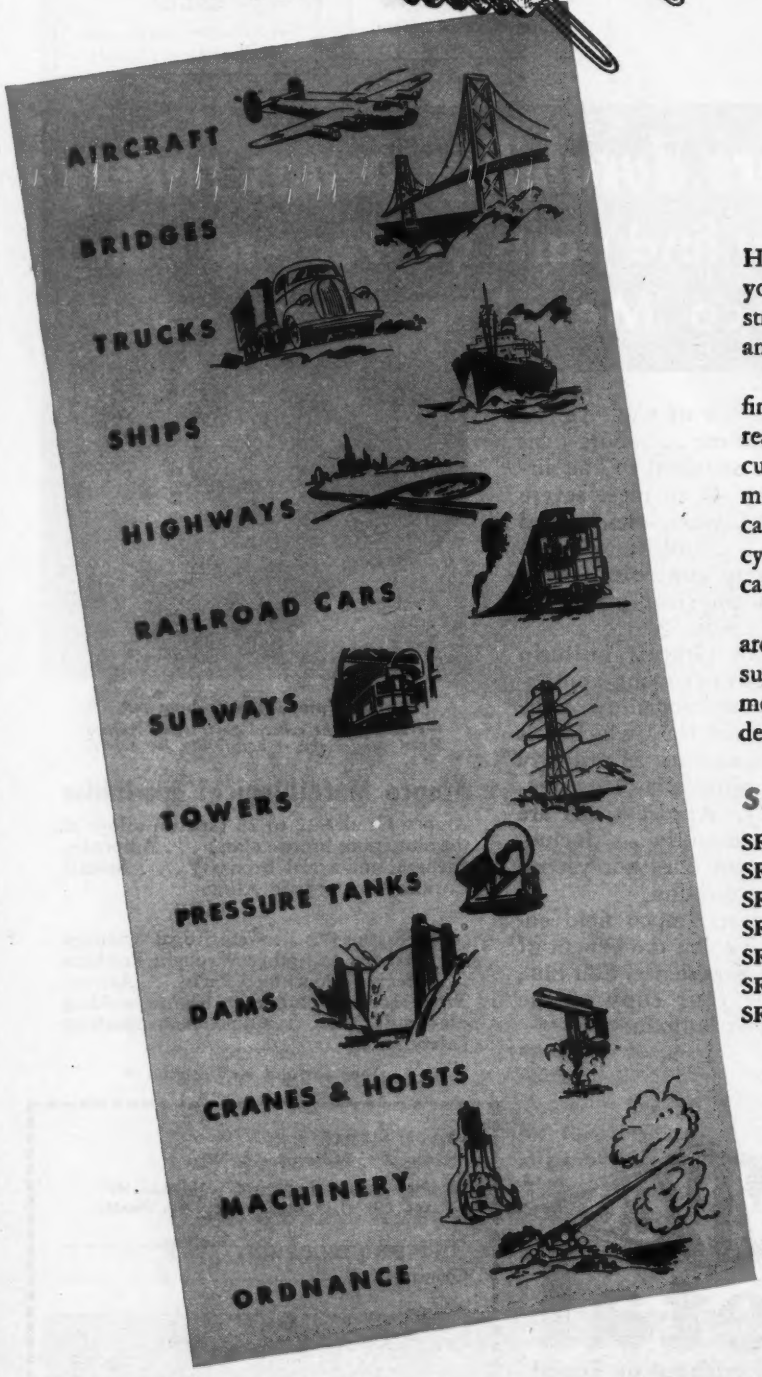

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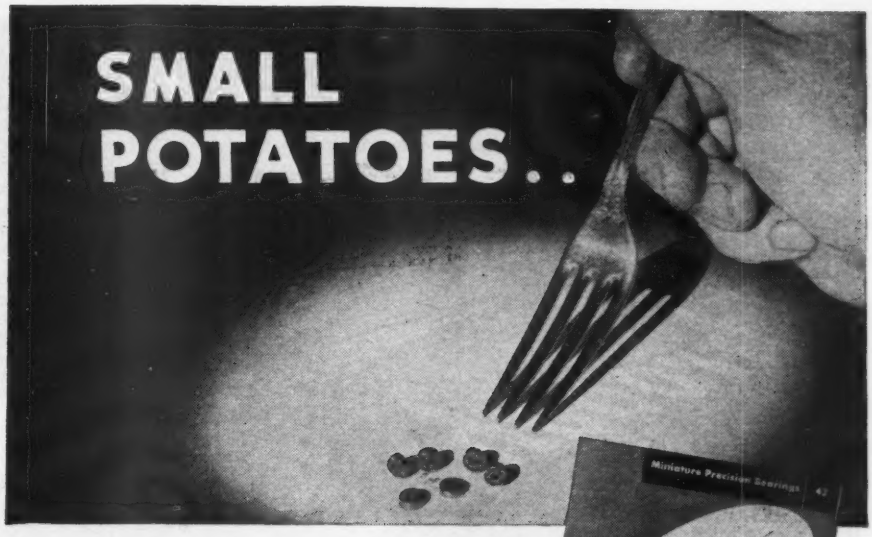
mary function of the high-altitude fighter is operation at maximum power at high altitude. In a particular case it might be found that an optimum cooler for standard-day operation would weigh 30 pounds, whereas the minimum for a very hot day would weigh 50 pounds. Whether even this increase is justifiable depends upon how much operation will be necessary in hot weather. Certainly it would be difficult to justify the optimum cooler for a hot day which might weigh 60 pounds. The loss in performance on a hot day with inadequate cooling is so severe (Reference 1) that the use of the 50-lb. cooler is probably justified unless it involves unusual penalties in the airplane arrangement. Since the vast majority of operation will be at temperatures near standard and sometimes colder, it is bad enough to have to use the 50-lb. cooler; a 60-lb. cooler, with all the penalties that would involve under normal conditions, in weight, drag, and arrangement, could not be tolerated.

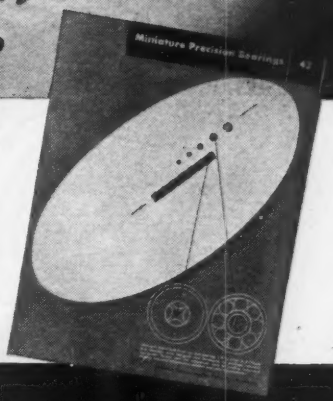
Determination of Optimum Intercooler Size

The methods used in the determination of the optimum intercooler size for the typical operating conditions are obvious and well-known, involving the balance of the power gain from reduced charge-air temperatures against the power loss, which consists of weight, and internal and external drag terms. Some discussion of the assumptions involved may be pertinent, since the answer is extremely sensitive to these assumptions.

Within the limits set by detonation and the vaporization difficulties mentioned, the charge-air temperature should be at the disposal of the intercooler designer, and considered as one of the primary variables instead of being limited to some arbitrary figure such as 90 deg. F. at the carburetor. Usually the optimum cooler will result in a temperature above that figure rather than below.

Weight: Another important assumption is the weight chargeable to the intercooler. The light weight of air-to-air intercoolers is deceptive, and it cannot be repeated too often that the weight chargeable to the addition of a particular item is not the weight of the bare item alone. Thus, we must add to the weight of the intercooler core the weight of the additional engine air ducts, the weight of the entrance and exit cooling air ducts, including their flexible seals, the weight of the flap which controls the cooling air exit area, the push-rod that operates the flap, the electric motor or hydraulic strut, the controls to the pilot's compartment, the flexible mount for the core, and perhaps instrumentation and regulating equipment. Some of these parts are subjected to high differential pressures, and all to vibration and temperature extremes. The exit flap, for example, often encounter limit design air loads of the order of 1,000 pounds per square foot at the design dive speed. Furthermore, if other units have to be rearranged to accommodate the installation, increases in weight of these units may be appreciable, and are chargeable to the intercooler. This may be especially important if heavy struc-





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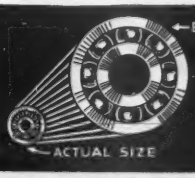

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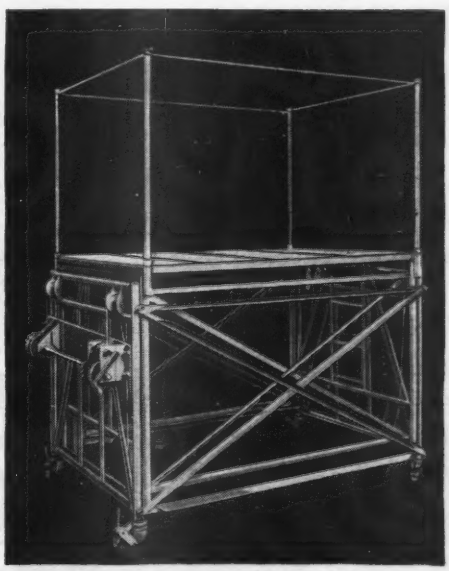

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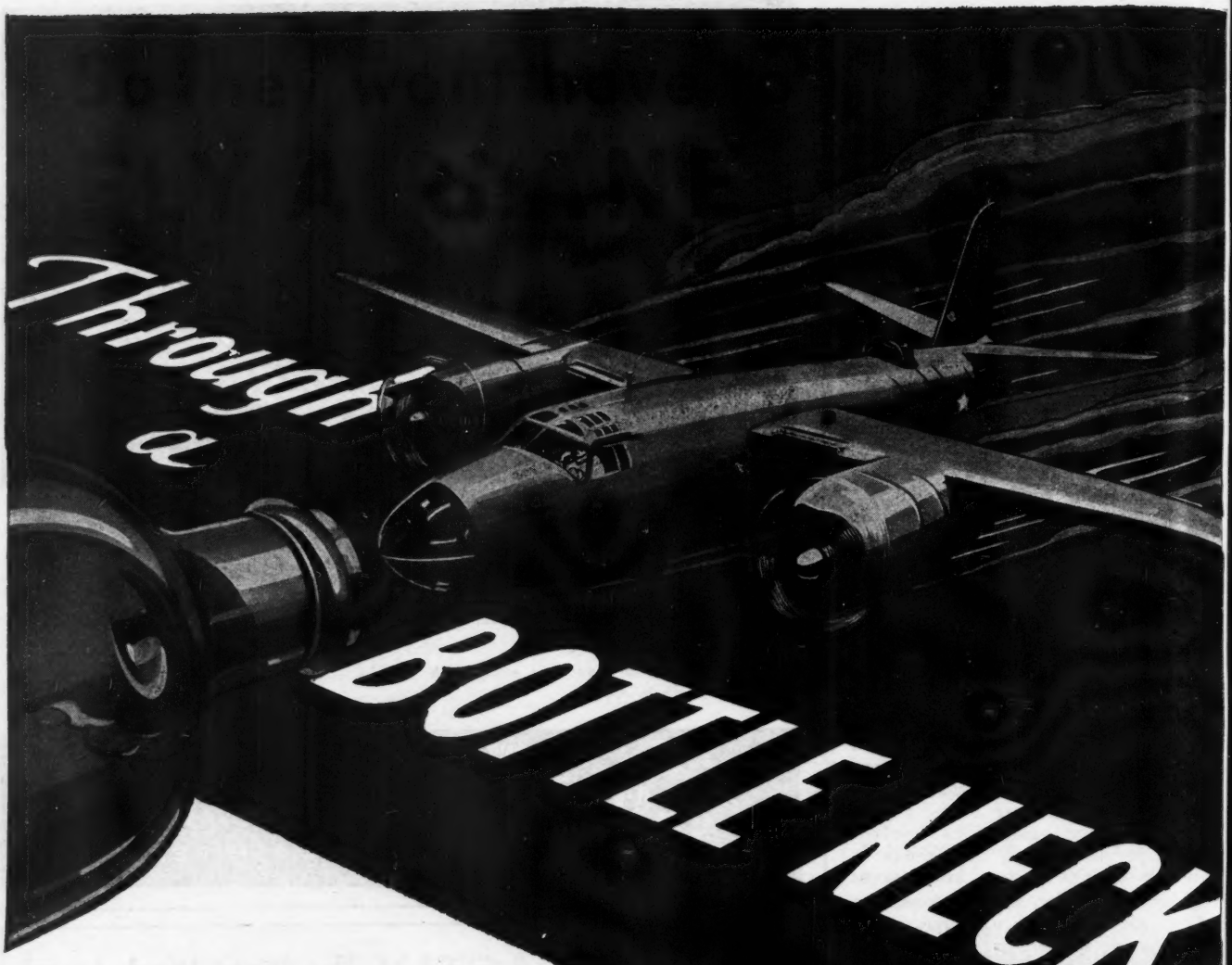

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tural members are compromised. Within the author's experience, these additional items will generally add up to about twice the weight of the core itself.

Beyond that, every pound of additional weight in the airplane requires additional gas if the range is to be maintained. Depending upon the airplane and upon the range, from .2 to .8 pounds of fuel and oil will be required per pound added to the weight empty.

This is obtained from the relationship:

$$\frac{\Delta \text{ Fuel Weight}}{\Delta \text{ Weight Empty}} = \frac{\text{Take off Gross Weight}}{\text{Take off Gross Less Fuel}} - 1$$

for constant range, which is derived from the Breguet range formula, as follows:

$$\text{Range} = K \frac{\eta}{C} \frac{L}{D} \log \frac{W_{TO}}{W_1}$$

where W_{TO} = Takeoff weight.
W_1 = Takeoff weight less fuel.

Consider an increase of weight empty, ΔWE. This will require additional fuel, ΔFW. Then, for the same range at the new take-off weight, $W_{TO} + \Delta WE + \Delta FW$,

$$\frac{W_{TO}}{W_1} = \frac{W_{TO} + \Delta WE + \Delta FW}{W_1 + \Delta WE}$$

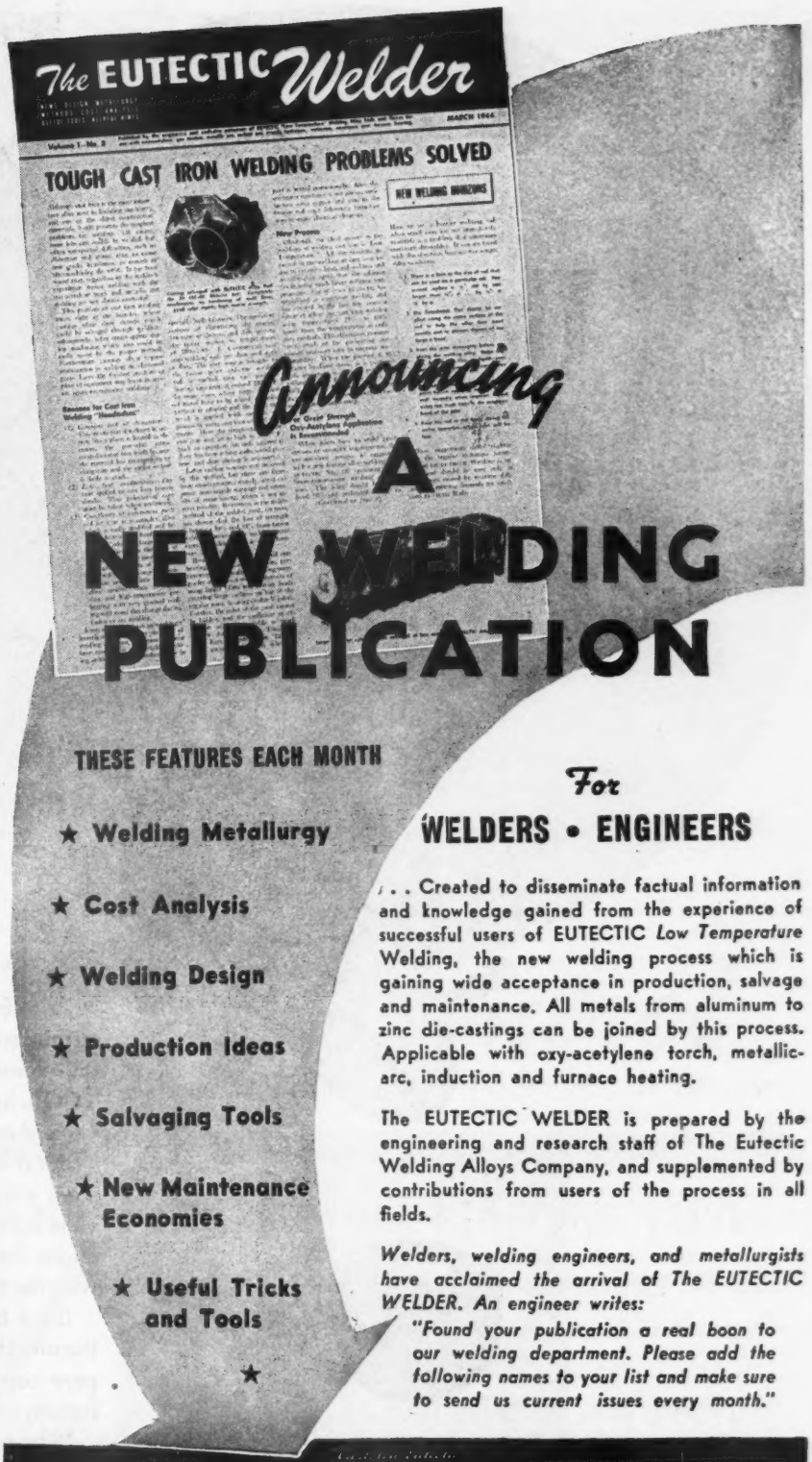
Whence $$\frac{\Delta FW}{\Delta WE} = \frac{W_{TO}}{W_1} - 1$$

Nor does the penalty end here. Additional tanks must be furnished to carry the additional fuel, and, in the case of military airplanes, bullet-proofing at probably .2 of a pound per pound of fuel must be provided. Lastly, as these weights are added to the airplane, other items will probably be added also, and sooner or later, important components must be increased in size. The landing gear is one such item which often becomes critical, so that it frequently occurs that a substantial weight increase in the landing gear must be charged off to a number of relatively minor increases in the weight empty of the airplane. Further, it is often necessary to maintain the wing loading constant to retain altitude, maneuverability, or landing or takeoff speed. In this case, wing area at perhaps four pounds per square foot must be increased. With a 40-lb.-per-square-foot wing loading, this means another .1 pound for each pound added, including fuel. All this weight in turn requires further increases in the fuel, so that the final increase in weight due to the intercooler could be expressed in the form of an infinite series which does not converge too rapidly.

The above items can be totaled roughly as follows:

Unit Core Weight	1 pound
Structure, ducts, etc.	2
Fuel = .4 x 3 =	1.2
Tanks and bullet-proofing = .25 x 1.2 =	.3
Wing area = .1 x 4.5 =	.5
Landing gear, further fuel, etc. = neglected	
	5.0 pounds

Briefly, it would be unduly optimistic to assess the weight of an intercooler in-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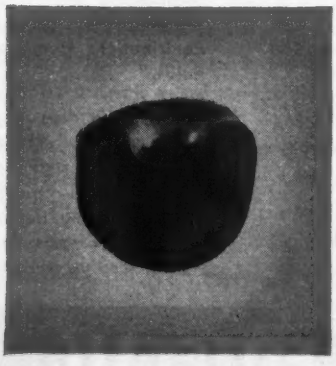

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stallation at less than five pounds per pound of core.

In connection with the external drag of the intercooler installation, one point is especially worth emphasizing. The system of ducts which must be provided with the cross-flow air-to-air intercooler makes this unit one of the most awkward to install in the entire power plant. A comparison of typical high and low altitude installations reveals that the difference in simplicity for the pilot, and frontal area are all out of proportion to the size of the intercooler itself. In calculating the optimum intercooler size, these factors, with the possible exception of frontal area, are generally omitted, not because they are unimportant, but because they are difficult to express quantitatively. It is easy to underestimate the increase in frontal area due to the intercooler, moreover, because part of it is in the form of frontal area of other components awkwardly located because of the presence of the intercooler.

In the most fortunate cases, the increase in frontal area due to the intercooler may be limited to little more than the duct entrance area required for the cooling air. This area will be that obtained by dividing the required cooling air flow by about .9 of the velocity ahead of the entrance in the climb condition. If the entrance is located in the slipstream, .9 of the slipstream velocity can be used. Thus:

A_e = entrance area

A_c = area of cooling air face of core

K = core conductivity, cooling air

$= (Q/A_c) / \sqrt{2p/\rho}$

Δp = available pressure drop across core

Assume:

$\Delta p/q = 1$

$q = \frac{\rho}{2} V^2$

V = velocity ahead of the entrance

$K = (Q/A_c)/V$

$A_e = Q/.9V = K A_c/.9$

If $K = .2$ is typical,

$A_e = .22 A_c$

So that the entrance area is about .2 of the core area. The minimum drag increment is obtai .ed, not with this increase in area, but by using a somewhat larger increase which permits better streamlining. Even this amount is often insufficient to accommodate the core. In some cases, a leading-edge inlet saves frontal area. Within the author's experience, however, this solution entails larger internal losses, great difficulty in avoiding lift losses, and profile drag increases on the wing that are sometimes small but rarely negligible.

The idea that the intercooler can simply be placed in the fuselage or nacelle in a convenient vacant space is, to put it generously, naive. This fact can be substantiated by a glance at the outstanding high-altitude fighters. In some cases, the frontal area of the nacelle, or, in the case of single-engine ships, of the fuselage including all cooling scoops but excluding the pilot's canopy, approaches twice the frontal area of the engine itself, an increase which is due primarily to items like the intercooler. A typical frontal area for an air-cooled installation with

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two stages of supercharging and intercooling is 24 square feet. The engine itself has an area of 17 square feet. In extreme cases, even larger ratios occur. In one case, an engine which could be concealed behind a 36-in. disc was used in a nacelle design which could not be concealed behind a 62-in. disc. In another instance, a 9-square-foot engine required a 15-square-foot nacelle. Yet, the "density" of these designs is remarkable. One could scarcely hang his hat inside the P-38 boom between the spinner and the Prestone radiator. Almost certainly, then, an intercooler installation will add frontal area greater by a substantial amount than the cooling air entrance.

Type of Charge-Air Cooling

The airplane designer has the choice of two types of charge-air cooling which are called "intercooling" and "aftercooling," depending upon whether the cooling unit is located between the stages of a two-stage supercharging system or between the second stage and the intake ports. He also has the choice of accomplishing the cooling by means of air-to-air intercoolers or with liquid-to-air intercoolers. The air-to-air system is the conventional arrangement, and the liquid-to-air system has only recently received favorable consideration. The liquid-to-air system differs fundamentally from the air-to-air system in that two units are required, a primary unit for the transfer of the heat from the engine air to the liquid and a secondary unit for the transfer of the heat from the liquid to the cooling air.

Since the second stage of supercharging must be integral with the engine in order to facilitate vaporization of the fuel and distribution between the cylinders the aftercooler must be inserted in a confined region, so that it also is practically integral with the engine. The practical problems involved in ducting in this arrangement appear to be insurmountable in the case of the air-to-air aftercooler, so that only the liquid-to-air aftercooler needs to be considered. Likewise, since the liquid-to-air system breaks down the cooling process into two separate steps, it practically doubles the intercooler effectiveness required for a given temperature difference between engine and cooling air. Accordingly, the liquid-to-air intercooler can immediately be eliminated from consideration because of the penalty in weight and size of the units which would be involved. Finally, then, we need only compare the liquid-to-air aftercooler with the air-to-air intercooler. This means that a discussion of intercooling versus aftercooling cannot be separated from a discussion of air-to-air versus liquid-to-air systems.

The fundamental advantages of the two systems are immediately obvious. The aftercooler works with higher temperature differences, due to the two stages of compression which precede it. The intercooler, on the other hand, makes possible higher blower efficiencies in the second stage of supercharging. As in many other airplane design problems, the deciding factors are not the obvious ones, and a decision as to which arrangement to use

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in a particular installation can best be reached by consideration of a number of small effects which require judgment rather than analysis to evaluate.

With the liquid-to-air aftercooler, one of the biggest advantages, from the standpoint of the airplane designer, is the flexibility in power plant installation arrangement which it makes possible. The awkward arrangement of ducts in the cross-flow air-to-air intercooler and their large size makes its location very critical and difficult to work out efficiently. It often requires a compromise in a great many other units of the power plant installation. Both units of the liquid-to-air aftercooler system are relatively compact, and require only one pair of air ducts in addition to the relatively small liquid coolant lines. Furthermore, the secondary unit of the aftercooler system can be removed from the engine compartment altogether and placed in any suitable location in the airplane without concern over the problem of ducting the engine air to the unit and back again. This makes possible its location in thin wings where a cross-flow unit would be quite impractical, or in remote portions of the fuselage or nacelle. This flexibility is especially advantageous in the case of the two-stage geared blower because the auxiliary stage of the blower can be located close to the engine without having to leave room for ducts to a large air-to-air intercooler. In the case of the turbosupercharger, the auxiliary blower is generally located far enough from the engine that space can be found for an air-to-air intercooler between the blower and the engine without prohibitive dislocation of the other elements of the installation. On the other hand, the crowding problem of the primary unit of the aftercooler is severe enough that it is doubtful whether maintenance problems would be alleviated by the use of this arrangement in even a majority of cases. Certainly the weight of the liquid-to-air system will be greater. Likewise, in the upright liquid-cooled engine, the location of the primary aftercooler unit may be such as to seriously interfere with pilot visibility. Another point is that the higher carburetor temperatures encountered with the aftercooler system may prove a very real advantage in improving the vaporization of fuel under adverse conditions. Finally, the duct losses involved in the turns into and out of the air-to-air intercooler subtract from the critical altitude of this type of installation. These losses probably can be avoided in the aftercooler arrangement.

Taking into account the various factors, it is seen that the two systems are comparable from the airplane designer's standpoint. It is doubtful, however, whether it would ever be desirable to suffer the complication and weight caused by the installation of a complete Prestone system on an air-cooled engine in which such a system was not already in existence for engine cooling. This is especially true since the shape of the air-cooled engine tends to create more space behind the engine for the installation of the air-to-air intercooler. Thus, in general, the increase in frontal area chargeable to an

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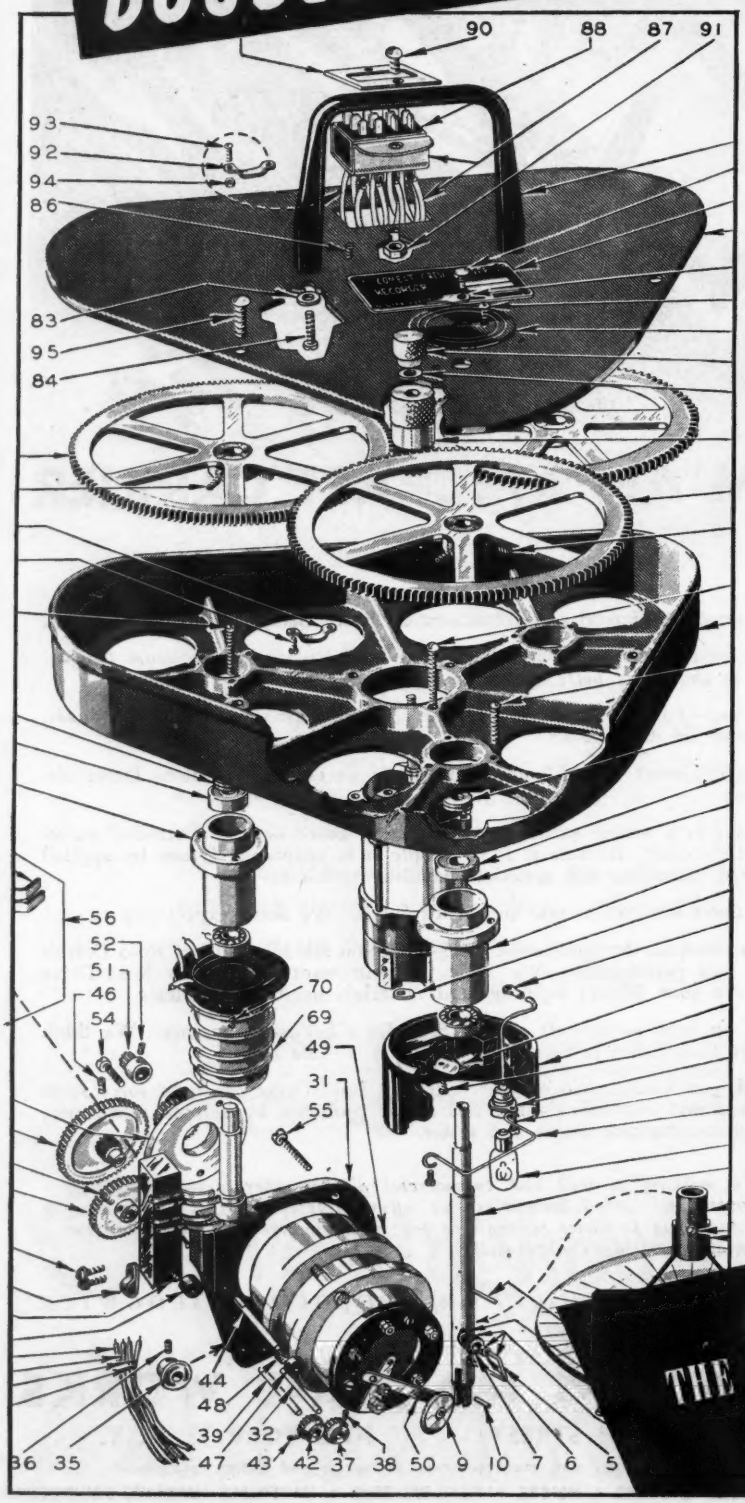

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air-to-air intercooler would probably be less in the case of an air-cooled engine than in the case of an equivalent liquid-cooled engine. On the other hand, the liquid-to-air system requires relatively little additional trouble in a liquid-cooled engine, and its greater compactness and flexibility are of more importance in such installations.

In large airplanes, generally, power plant interchangeability and maintenance dictate a trend toward concentration of the power plant in the nacelle. Also, this field has thus far at least been dominated by the air-cooled engine. Consequently, the use of liquid-to-air intercooling does not appear probable in such installations.

On the other hand, on smaller airplanes, the decentralization of the power plant may be extremely desirable for improved aerodynamic efficiency, and the possibility of isolating the secondary cooling in a separate unit located at a distance from the nacelle and probably combined with the Prestone radiator may be a big advantage. Therefore, in small airplanes with liquid-cooled engine installations, the liquid-to-air aftercooler appears to offer definite advantages to the airplane designer.

Ultimately, as critical altitudes are pushed higher and higher, the power required to supercharge the engine will become of primary importance. For such extreme altitude operation, two stages of intercooling may be desirable, one an intercooling stage and the other an aftercooling stage. In such an arrangement, the liquid-to-air system appears to be definitely superior from the standpoint of compactness.

Installation Problems

The primary installation problem is, of course, the location of the unit. The air-to-air intercooler is the most difficult of all engine accessories to locate satisfactorily because it is necessary to provide four air ducts to it as against two for the Prestone and oil radiator; all four of these are of about the same relative size as the air ducts approaching and leaving the Prestone radiator; the charge air and cooling air both must generally travel in a fore-and-aft direction, so that one system must be compromised to the extent of two 90 deg. turns in order to conduct the air laterally or vertically through the core. This problem could be avoided to some extent in a counter-flow instead of a cross-flow type of intercooler. A discussion of the relative merits of these types will be left to those better qualified: it is enough for our purposes that a good counter-flow cooler is not now available commercially and that a good solution to the header problem taxes the imagination.

Considering, then, only the cross-flow intercooler, the frontal area of the core and ducts will always be greater than the core face even if space limitations permit tilting the core. This latter device reduces the over all height or width and reduces the angles through which the crossing air must be turned, but if it crowds adjacent items or compromises structure, the gain is offset by increased frontal area, less accessibility, or increased weight. In any event, the frontal area required for installing the air-to-air intercooler will be from 120 to 200 percent of the core face, while the liquid-to-air cooler will require a header whose area is perhaps only 20 percent of the core area and whose shape is not critical, besides coolant lines of an inch or two in diameter. Thus, while it is difficult to put an air-to-air intercooler in a fighter wing, Prestone and oil coolers so installed are common.

The header problem for the crossing air is particularly difficult. Large pressure losses are likely, and uniform flow over the core face is rare. It is not uncommon to encounter an area expansion of 100 cent or more in the width of the core, coincident with a 90 deg. turn and a transition from a circular to a rectangular section. This situation is hardly improved by casual recommendations of 14 deg. maximum expansion angles in straight ducts, of ratios of outer to inner radius of not greater than two, etc. The use of sheet metal guide vanes has the disadvantage that even if both the duct and the vanes are made very heavy they invariably crack out under vibration and go through the engine.

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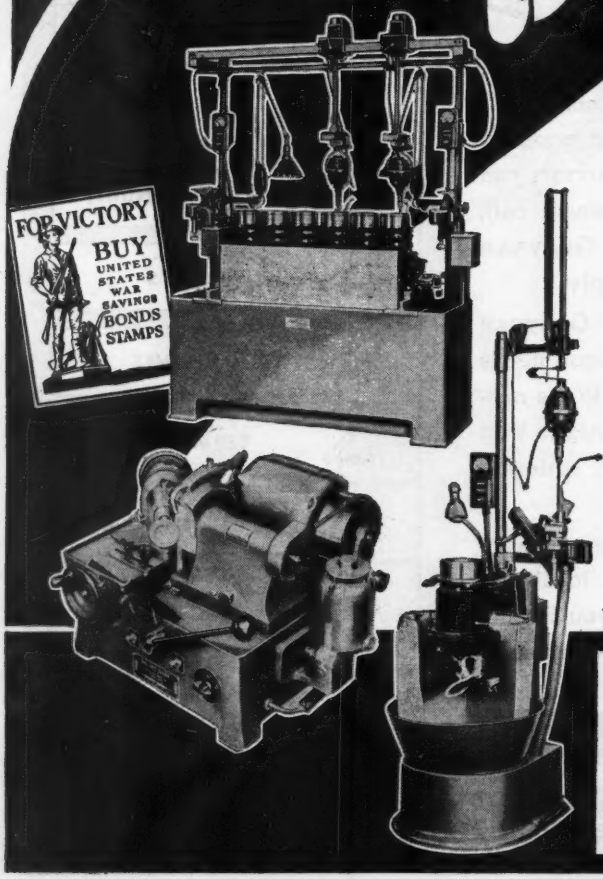

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ing the frontal area of the nacelle or fuselage to make possible a better turn into the core. An engineering approach to the problem can be achieved by comparing the performance losses resulting from the loss in brake horsepower due to pressure loss in the duct system if the bad turn is retained on the one hand, and the effective brake horsepower loss due to the higher external drag on the other. This is best illustrated by an example.

Consider an 1,800-brake-horsepower engine in an airplane capable of 450 miles per hour at 30,000 feet. (All numbers, of course, are purely hypothetical.) First, the drag increase per square foot increase in frontal area is calculated, and this drag increase translated into equivalent loss in brake horsepower. In an actual case, the designer will know how much increase in frontal area will be required to improve the bad spot in the induction system layout. He can also obtain a fair estimate of the reduction in pressure drop which will be realized with the better system. This reduction in pressure drop will provide an equal increase in manifold pressure, which can be translated directly into brake horsepower. The two alternatives are then compared on the basis of brake horsepower.

In the case under consideration, if the frontal area is increased, there will be an effective loss in brake horsepower of about 30 brake horsepower per square foot increase in area for high speed operation at 30,000 feet, and about 75 brake horsepower per square foot at sea level at the same speed. These figures are based on an assumption of 75 percent propeller efficiency and a drag coefficient of .08 based on the increase in frontal area.

In calculating the saving in power loss due to cleaning up a bad turn, the assumptions will be kept on the optimistic side so that the *maximum* probable saving will result. This will assist in evaluating the comparison. Now, the pressure loss in a bad turn may easily equal the dynamic pressure in the duct upstream of the turn, which will be called "*q*", and it is a very good turn indeed with costs less than $\frac{1}{4}$ *q*. The turn can be improved by expanding the duct upstream of the turn of increasing the ratio of the inside to the outside radius or both. Either change would probably increase the frontal area. A fairly optimistic figure for the reduction in pressure drop might be about half of the *q* ahead of the turn in the original set-up. With a specific air consumption for the engine of about .12 pounds per brake horsepower per minute, a velocity of about 200 feet per second occurs in a six-inch-diameter circular duct, the absolute pressure being about 35 inches of mercury, and the temperature about 285 deg. F. The corresponding *q* is 80 pounds per square foot, so the likely saving is .5 inch of mercury. For an engine which will produce 1,800 brake horsepower at 60 inches of mercury manifold pressure, a reasonable estimate of the variation of power with manifold pressure at constant rpm. would be about 35 hp. per inch of mercury, so that an improvement of .5 inch would produce about 18 additional brake horsepower.

Thus, in the case considered, we can only justify an increase in frontal area of half a square foot at the most in order to make a bad turn into a good one. An increase in diameter of a typical air-cooled engine cowling of only $\frac{3}{4}$-inch will produce an additional half square foot, however. In the preliminary phases of a design, before tooling and production consideration make such studies purely academic, a power plant installation can be laid out both ways, that is, first with all ducts squeezed to the utmost, and second, with the ducts designed for moderate losses. A comparison of internal and external performance of the two arrangements will yield an answer, which, if interpreted with judgment, will serve as a reliable guide. It will seldom be found worthwhile to sacrifice frontal area to save duct losses.

It should be noted that there is another way of looking at the above comparison which places the increase in frontal area in an even less favorable light. If the frontal area is increased, the speed attainable with a given engine power is reduced at all altitudes and cannot be regained. The effective power loss is especially severe at low altitudes, which are not always insignificant to the high altitude

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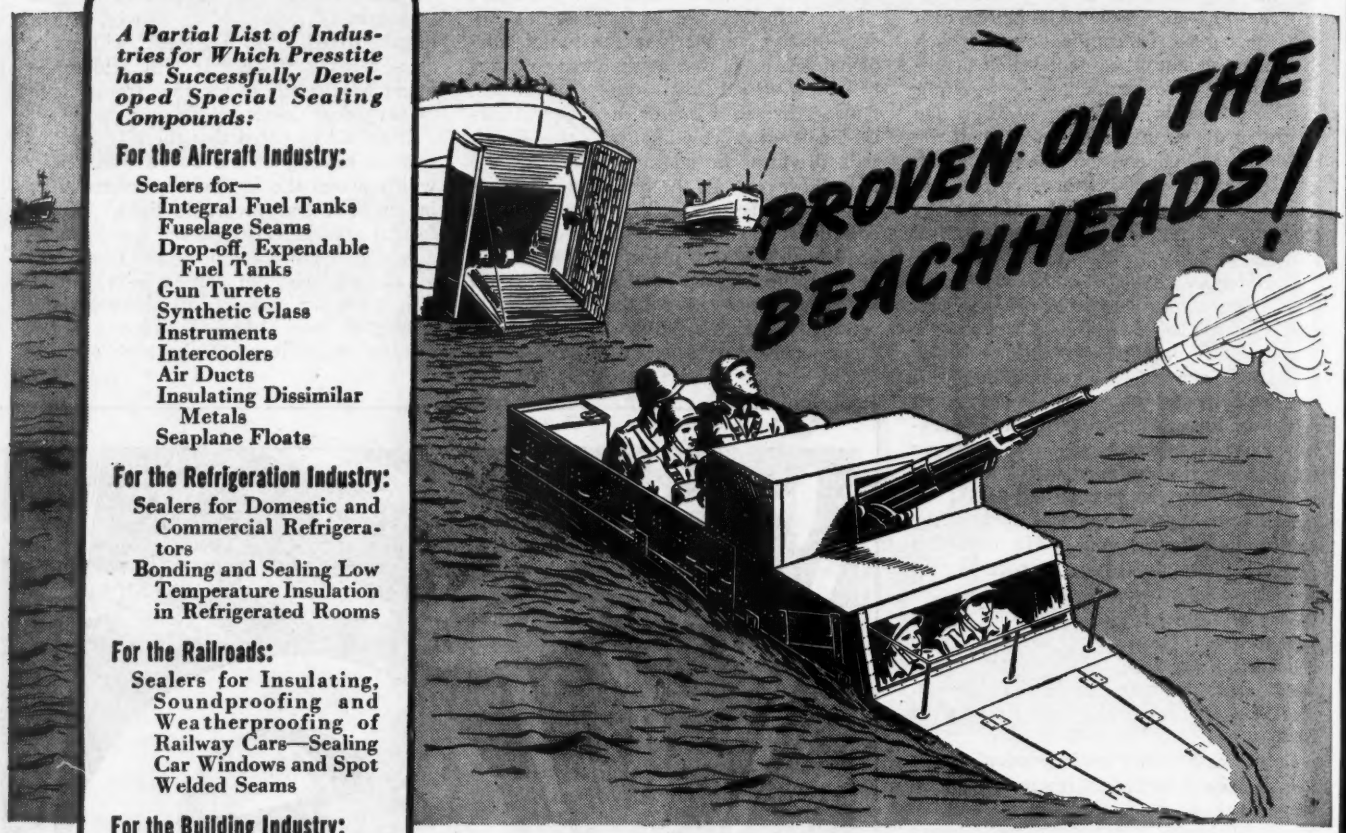

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fighter. Duct losses, and for that matter, intercooler pressure drops themselves can be made up at altitudes below the critical altitude by increasing the output of a turbosupercharger or opening the throttle wider with a geared blower. Thus duct losses simply reduce the critical altitude without affecting the performance below the critical,* whereas increased frontal area affects the performance at all altitudes. In the example cited, the loss of .5 inch of mercury in one bad turn would reduce the critical altitude about 1,000 feet. This is a severe loss, but below 29,000 feet the turning loss would have no effect.

Miscellaneous Installation Problems

One installation problem which gives considerable difficulty is the structural problem. Not only must the primary structural loads be carried around the intercooler duct system, but also the intercooler must be insulated from the structural deflection. This is usually accomplished with rubber bushings which also help to reduce the vibration to which the intercooler is subjected. The necessity for four ducts to the core make the problem of routing structure around the intercooler particularly difficult. Accordingly, there is generally a considerable weight penalty chargeable to the intercooler installation which is greater than for the Prestone and oil cooler installations. Also, the structural difficulty for the intercooler limits the locations which may be selected.

The problem of protecting the induction system and especially the charge-air coolers from the pressures developed in back-fires, has not yet been satisfactorily solved. The use of back-fire screens is impractical because of the large loss in manifold pressure which results from their use. Various types of relief valves have been tried without success. The only practical answer at the present time seems to be to design the systems for internal pressures of about 100 pounds per square inch, which appears to be sufficiently high to provide reasonable assurance against damage. This requirement results in a considerable weight penalty.

The fatigue problem is acute in the charge-air system because of the large variation of temperatures and pressures to which the system is subjected. Also, space, and in many cases, aerodynamic conditions, favor non-circular ducts. Under high differential pressures, these ducts tend to become circular, and the large deformations encountered produce crackling.

A number of attempts have been made to employ automatic regulation of the carburetor air temperature by thermostatically controlling the outlet flap on the intercooler cooling-air duct. Unfortunately, there is little thermal capacity in the system, so that with air-to-air intercoolers, extremely rapid response is needed from the control. For instance, if the airplane is cruising at low power at high altitude, and the pilot suddenly increases the power, the carburetor air temperature reaches its maximum value as soon as the engine comes up to speed, or in the case of the turbosupercharger, as soon as the turbo speed is increased. In general, a few seconds of detonation will cause severe engine damage so that the practically instantaneous cooling is needed. Under the circumstances in which sudden power increases are necessary, the pilot should not have to concern himself with the adjustment of intercooler flaps. Unfortunately, thermostatic controls having an adequate rate of response are not yet available.

The problem of preventing excessive leakage in the system has found no entirely adequate solution. Leakage, however, is not as serious as some other difficulties because at altitudes below the critical it causes very little power loss. This follows from the fact that the supercharger is generally working on the flat part of the curve of efficiency against air flow. Moderate increases in the air flow do not have any appreciable effect on the efficiency. However, at the critical altitude, with the turbosupercharger, the output is limited by the maximum turbo rpm. and with the geared blower, full throttle is the limitation. In either case, an increase in the air flow due to leakage makes available a reduced pressure rise from the blower with consequent loss in critical altitude.

* Neglecting a slight increase in charge-air temperature and a back pressure from the turbo.

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